JOURNAL OF MAMMALOGY

VOL. 37 MAY 1956 NO. 2

QL
1
.J86

UNIVERSITY OF MICHIGAN
JUN 14 1956
FORESTRY LIBRARY

AMERICAN SOCIETY OF MAMMALOGISTS

The American Society of Mammalogists

Founded April 3, 1919

Incorporated April 29, 1920

Officers

WILLIAM B. DAVIS, *President*
ROBERT T. ORR, STEPHEN D. DURRANT, *Vice-Presidents*
RANDOLPH L. PETERSON, *Recording Secretary*
GEORGE C. RINKER, *Corresponding Secretary*
CAROLINE A. HEPPENSTALL, *Treasurer*
W. ROBERT EADIE, *Editor*

Additional Directors

1955–1957	1954–56
VIOLA S. SCHANTZ	KEITH R. KELSON
EMMET T. HOOPER	DONALD F. HOFFMEISTER
J. KENNETH DOUTT	KENNETH L. DUKE
OLIVER P. PEARSON	ANTOON DE VOS
WILLIAM V. MAYER	HOBART M. VAN DEUSEN

Past Presidents

HAROLD E. ANTHONY	E. RAYMOND HALL
H. H. T. JACKSON	REMINGTON KELLOGG
WALTER P. TAYLOR	TRACY I. STORER
A. BRAZIER HOWELL	WILLIAM J. HAMILTON, JR.

WILLIAM H. BURT

Trustees

STEVEN S. GREGORY, JR. (1957) WILLIAM P. HARRIS, JR. (1956) D. DWIGHT DAVIS (1958)

Standing Committees 1955–1956

Bibliography: David H. Johnson, *Chairman*. Claude W. Hibbard, Henry W. Setzer, Richard G. Van Gelder, Charles P. Lyman, Richard H. Manville.

Conservation of Land Mammals: Helmut K. Buechner, *Chairman*. William O. Pruitt, Jr., Antoon de Vos, William J. Hamilton, Jr., Bryan P. Glass.

Editorial: W. Robert Eadie, *Chairman*. Don W. Hayne, Donald F. Hoffmeister, Claude W. Hibbard, William A. Wimsatt.

Honoraria for Graduate Students: Stephen D. Durrant, *Chairman*. Robert T. Orr, Frederick S. Barkalow, Jr.

Index of Journal of Mammalogy: Viola S. Schantz, *Chairman*. Charles O. Handley, Jr., David H. Johnson, Henry W. Setzer.

Marine Mammals: Robert T. Orr, *Chairman*. Robert B. Chiasson, H. Dean Fisher, Raymond M. Gilmore, Gordon Gunter, Carl L. Hubbs.

Membership: Albert R. Shadle, *Chairman*. Randolph L. Peterson, Arthur Svihla, Bryan P. Glass, Kenneth L. Duke, William V. Mayer.

Nomenclature: E. Raymond Hall, *Chairman*. Donald F. Hoffmeister, Emmet T. Hooper, Philip Hershkovitz, Kenneth Stager, Karl F. Koopman, C. O. Handley, Jr.

The American Society of Mammalogists is an affiliate of the A. A. A. S. and the National Research Council, and an exchange member of the Nature Conservancy.

The Journal of Mammalogy

Journal of Mammalogy is published quarterly by the American Society of Mammalogists, Mt. Royal and Guilford Aves., Baltimore 2, Md.

Persons actively interested in mammalogy may become members of the Society upon nomination, payment of membership dues, and election. Applications for membership may be obtained from the corresponding secretary. The Journal of Mammalogy is sent free to all members of the American Society of Mammalogists not in arrears for dues ($4.00).

Subscription rates are $6.00 per year; single numbers of the Journal are $1.50 each.

Nominations and dues for membership, dues for subscriptions, changes of addresses, orders for back numbers and the two bound indexes, requests for missing numbers, and applications for advertising rates should be addressed to the Corresponding Secretary, George C. Rinker, Department of Anatomy, University of Michigan, Ann Arbor, Michigan.

Publications for inclusion in the bibliography of mammalogical literature, section on "Recent Literature," should be sent to David H. Johnson, Division of Mammals, U. S. National Museum, Washington, D. C.

Manuscripts for publication, books for review, and papers for special comment should be sent to the Chairman of the Editorial Committee, W. Robert Eadie, Fernow Hall, Cornell University, Ithaca, New York.

Entered as second class matter, November 22, 1919, at the Postoffice, Baltimore, Md.; under the act of March 3, 1879.

Made in United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 37 MAY —, 1956 No. 2

BEHAVIOR OF COLUMBIAN BLACK-TAILED DEER WITH REFERENCE TO POPULATION ECOLOGY

BY RAYMOND F. DASMANN AND RICHARD D. TABER

An understanding of animal behavior is essential to any study of population ecology. The dynamics of a population, including changes in natality, mortality, density and structure are strongly influenced by behavioral elements such as mobility, territoriality and social organization. These elements of behavior have been investigated for the Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson), in Lake County, California. The findings for this area, with comparative data from the literature on *Odocoileus* and, where appropriate, other Cervidae, form the body of this report.

The present study was made in the north coast ranges of California, about five miles southwest of Lakeport in the Scott Creek drainage. Work in this area was begun in 1948. Detailed studies of behavior were carried out in the period 1951 to 1953, with further checks being made in the summers of 1954 and 1955.

In the study region the principal plant complex is chaparral. This is an assemblage of fire-adapted shrubs, which respond to burning either by sprouting from the root crown, or by having seeds that are stimulated to germinate by fire. In this area the chaparral is broken into distinct north and south exposure aspects, the former dominated by interior live oak (*Quercus wislizenii*) and the latter by chamise (*Adenostema fasciculatum*). Many other species of the same general growth form also occur in smaller numbers.

Large fires have frequently swept the region since white settlement about a century ago. The south-facing slopes, being more warm and dry, burn more often and more completely than the north exposures, where a residue of fire-killed limbs and new growth forms an almost impenetrable tangle. Where the topography has protected north slopes from fire a broad sclerophyll forest develops (Cooper, 1922).

During the summer the deer bed and feed on the cooler north slopes, venturing into the more open south slopes after dark. In the winter the north slopes are apparently too cold, as are the deep canyon bottoms, and the deer feed and bed mainly on south exposures. The heavy brush of the north slopes is used as fawning cover, and as escape cover at all seasons. Riparian woodlands of white oak (*Quercus lobata*) and other species are important to the deer in the fall when the acorns are ripe, and in early summer when fawns are small.

The extent of any one slope is not great, since most of the ridges are under 500 feet from base to crest, and the average slope is about 22 degrees. The substrate consists of sandstone and shale, forming under these conditions a shallow Maymen soil. Smaller areas of deeper and more fertile soils—Los Gatos, Hugo, and Josephine—were found to constitute the preferred feeding areas for the deer.

The climate of the study region is Mediterranean, with warm, dry, fog-free summers, and cool, rainy winters. The average annual precipitation (Lakeport) is 28 inches, of which a little falls as snow, but this seldom remains long upon the ground.

The deer of the study region are smaller than is usual for the subspecies, and the males have smaller antlers. Average live weights for bucks fall between 90 and 130 pounds, and for does, between 70 and 90 pounds. The deer are adapted to living on the outskirts of human settlement. Their behavior is influenced by their habitat, created in part by man-caused fires, and is adjusted to the occasional presence of man and his domestic animals. The presence of observers within the area created no unusual disturbance, and did not modify the normal behavior of the deer.

The terrain favored the direct observation of deer. From vantage points on hills and ridges it was possible to watch deer over a wide area and record their movements and activities. Even the dense brush, which provides effective cover from the sides, does not provide an overhead screen. An observer on a hill or ridge can look into this cover and see those deer that are moving about. Bedded deer, however, are difficult to detect.

Within the general study region an area of about 400 acres was selected for

TABLE 1.—*Deer population on the 400-acre study area in 1951–1953*

Period	Adult males	Yrlg. males	Adult females	Yrlg. females	Fawns	Total
1951						
June	16	6	23	10	35	90
August	15	6	21	10	23	75
October	7	6	20	9	18	60
1952						
January	6	6	20	9	14	55
May	6	5	16	7	9	43
June	11	2	23	7	29	72
August	11	2	23	7	25	68
October	9	2	23	7	23	64
1953						
January	9	2	23	7	21	62
May	7	2	22	3	9	43
June	9	4	25	5	24	67

intensive population investigations. This area, referred to henceforward as the study area, was censused by various methods, and shifts in population structure were followed over several years (Dasmann and Taber, 1955*a*, *b*). As an aid to these studies and the behavior studies, deer were live-trapped and individually ear-tagged in the study region. These deer could be recognized, with a telescope, up to one quarter of a mile away.

During the fall and winter of 1951–52 there was severe mortality, with 44 per cent of the summer population being lost. This per cent of loss was not approached in subsequent years. In general, there was a tendency for the deer population on the study area to decline during the period of study.

The summer population density ranged from 144 deer per square mile in June, 1951, to about 90 in June, 1954. The pre-fawning density also declined from about 90 per square mile in May, 1951, to 55 in May, 1954. Natality, as determined from fawn counts varied from 152 fawns per 100 adult does in July, 1951, to 96 in June, 1953. In subsequent years it was about 100:100. Deer populations and their structure on the study area from June, 1951, to June, 1953, are summarized in Table 1.

ANNUAL CYCLE OF ACTIVITY

The seasons in the study region are not delimited as sharply as they are in many places, partly because there is no period of prolonged snow, but mainly because the vegetation is predominantly evergreen. However, seasonal changes occur, and have an influence on the behavior of the deer. The first rains fall in September or October, causing the growth of herbaceous plants. During December and January, and sometimes February, it is too cold for much plant growth. In February and March the principal growth of herbs occurs, followed by the growth of shrubs in April and May. Considerable food remains succulent in June, which is a good time for deer, but the rains are over and the vegetation is beginning to dry. Throughout summer and early fall there is no rain and the forage drops steadily in quality.

Summer.—The deer year begins in May, the month when most of the fawns are born. At this time adult does are in dense brush, where they remain during most of the early weeks of the fawn's life. The bucks, however, are out feeding in open areas, and are more conspicuous than later in the year. When the weather is cool in May and June the deer may be active throughout the day. By mid-July antler growth in the males has been completed. The does and fawns leave the dense brush by this time and appear regularly to feed in the open.

With increased daytime temperature and decreased humidity the activity of the deer forms a pattern that persists until cooler autumn days. The early morning sunlight seems to stimulate the deer to rise from their beds and begin feeding. Deer in cover move out into the open. North-facing slopes, burned over and rich in sprouts of oak and laurel, are favored feeding grounds, particularly preferred by does and fawns. Bucks are more often on the higher ridges and south exposures. The deer tend to follow the line of sunlight and shade down the north-facing slopes as the sun rises. When the entire slope is illuminated the movement toward bedding cover may begin. Some deer move down into the canyon bottoms and continue feeding during the late morning, but by afternoon nearly all will be bedded in dense brush.

In late afternoon, temperatures decrease and a brisk west wind may blow. Deer move from their beds and begin the evening's foraging. The activity increases as the hour grows later, and a peak may be reached in the early hours of darkness.

During late July and early August bucks are less evident. The older males in particular move into heavy cover. This coincides with velvet shedding which extends from about

July 20 to August 10. During shedding bucks may be observed rubbing their antlers on brush and trees.

Hunting season.—Hunting season begins at a time when daytime temperatures are high, and the older bucks are in dense cover. Only bucks with two or more points on at least one antler are legal game—two-year-old bucks or older. When the season begins, does, fawns, and young males appear in the feeding areas in early morning as usual, but these are often the only deer that the hunter sees. The opening day of hunting brings a complete disruption of the normal routine for the deer. Hunters, dogs, and horses arrive in numbers, crashing, shouting, and shooting. The older deer may immediately seek shelter and remain close to their beds. The less experienced deer are confused. Groups scatter, and deer run in several directions, with the younger males making excellent targets by running across open ground. After opening day few deer frequent the open. A search of the dense brush may reveal many. Thus, on opening morning of hunting season in 1952, in an area where over 100 deer lived, only three deer, all fawns, were visible in open areas.

During late August and early September the number of hunters decreases, and the deer become adjusted to this lower level of disturbance. Does, fawns, and young males resume activities similar to those of July, and flee only when a hunter approaches. The older males, however, if previously hunted, avoid open areas. Cooler weather at this time may bring more deer into the open during the middle part of the day.

The results of the hunt are a heavy loss in two-year-old bucks, and a smaller percentage loss of older males. Bucks show ability to learn about hunting from experience, and the behavior of the older males differs from that of two-year olds. The normal tendency for deer is to flee from the close approach of man or dog. Yet, during the hunting season, old bucks will remain bedded and permit a hunter to pass within a few yards, and when in dense brush will stay in place and fight off dogs rather than flee from them. Escape, when disturbance comes close, is often by sneaking away, without noise, rather than the crashing and bounding escape typical of other seasons.

The hunting season brings physical changes. Most deer assume their winter coats; yearling males develop hard antlers; and the period of lactation for does comes to an end. By mid-August the fawns are already feeding on the same forage as the adults. Despite this, they are still willing to suckle. The does, however, move off, or butt the fawn away, when nursing is attempted.

Post-hunting season.—Late September and early October is a transition between hunting season and the rut. It is marked by cooler weather and often by early rains. This permits a prolongation of the daily feeding periods, and the deer are often seen during mid-day. Acorns begin to ripen, and attract deer to the old oak brush or the riparian woodlands.

Rutting season.—Physiological changes preceding the rut may begin in early September, when swollen necks are found on some males. Behavior changes become apparent early in October. There is increasing activity to a peak in late October and early November. After mid-November there is little rutting activity. The approach of the rutting peak is marked by an increase in the number of bucks visiting the area; an increasing association of bucks with does; an increase in aggression between bucks; and finally by active courtship (Table 2).

Prior to the rut, green grass may appear, and along with acorns, add to the forage supply. This influences the condition of deer entering the rut. Rains fall at intervals and the intermittent streams begin to flow.

Deer become active throughout the day and spend much time in the riparian woodlands. Bucks, not normally resident, visit the area in search of does. All bucks are more conspicuous, occupying commanding heights from which they can search the surrounding area, or travelling widely from one doe group to another.

Sexual combat between bucks, involving the use of antlers, was rarely seen. There was, however, occasional aggressive display among the bucks,—usually confined to threats without conflict. Most of the time, bucks associate but little during the rut, but occasionally groups of two to four males may form. In these groups, one buck is clearly dominant. We

TABLE 2.—*Sequence of events during rutting season*

Events	1951						1952			
	Oct. 1–3	Oct. 18–25	Oct. 30–Nov. 1	Nov. 5–7	Nov. 13–14	Nov. 26	Nov. 1–2	Nov. 8–10	Nov. 16	Nov. 29–30
Number of bucks seen per day	2.7	5.6	*6.3*	4.0	2.5	0.0	*6.5*	3.0	1.0	4.5
Number bucks with does per day	0.7	2.4	*3.7*	2.2	1.0	0.0	*3.0*	0.0	0.0	0.5
Aggressive incidents between bucks per day	0.0	*0.8*	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Courtship incidents per day	0.0	0.8	1.0	*1.5*	0.0	0.0	*1.5*	0.0	0.0	0.0

have no concrete evidence that dominant bucks do most of the breeding, but suspect that this is true.

Courtship behavior in deer has been thoroughly described by Linsdale and Tomich (1953). We have one additional behaviorism to report. On this occasion, courtship play was watched in which the doe and buck engaged in short chases and retreats, circling around a small brush patch, first in one direction, then in the other. The doe attempted to keep the brush patch between her and the buck. If the buck lost interest, the doe would approach him closely, and apparently attract him to further pursuit. This activity resembles the behavior of the roe deer engaged in courtship play in a roe ring, described by Matthews (1952).

Copulation was not observed. It may be that this activity, as well as battles between bucks, is confined to the night-time hours when it is cooler. Darling (1937) has reported that sexual activity in red deer is stimulated by reduced temperatures, and reaches a peak during the hours of darkness. This might explain the more frequent reports of observed copulation among migratory deer on winter ranges (Jones, 1954; Dixon, 1934), where the rut occurs when the weather is cold.

Rutting behavior is promiscuous, with bucks seeking more than one doe, and does accompanying more than one buck. There is no pairing, or harem formation. Fawns and yearling bucks in this area show no interest in the rut, and spend much time bedded or in dense cover. The sexual inactivity of yearling males in this area is not characteristic of the species in general; for reports of yearling breeding are in the literature (Dixon, 1934).

Bucks were found to feed regularly during the rut. Much more time is spent in other activities than feeding, but a considerable amount of forage is nevertheless consumed.

Early winter.—Following the rut is a period when the bucks apparently retire to heavy cover. This may correspond to the retirement of rutting red deer stags to the mountain tops following a period of activity among the does (Darling, 1937). After the first week of December, the bucks again seek open ridges and south exposures. Antler shedding occurs suddenly about one month after the rut, and all bucks may shed their antlers during a one-week period in mid-December, in the study area. In surrounding areas, at higher elevations, the period of antler shedding falls slightly later. Yearlings retain their antlers about two weeks longer than adults.

Does and fawns begin to move upward short distances to seek the warmer ridge tops and south-facing slopes. The north-facing and canyon bottom feeding grounds become deserted as winter temperatures fall, and are rarely used except for travel. There is a marked decrease in the wariness of bucks, and groups may be closely approached that would have fled during summer or fall.

Rain continues at intervals and the temperature is often near freezing. Snow may fall, but quickly melts. The larger creeks rise to flood stage, and cannot be forded by deer with-

out hazard, so that those with ranges crossing streams are confined to one side during the time of flood.

Late winter and spring.—Deer are often active throughout the day in late winter and spring. Mixed feeding groups of both sexes may form. There is a gradual break-up of the families which culminates in late spring when the yearling does drift off to produce fawns of their own, and the adult does show marked antagonism toward their past-year's fawns. The fawns are repelled whenever they approach close to the doe, and may be driven off. The usual tendency, however, is for the fawn to remain in the vicinity, and rejoin the doe again after the new fawns are old enough to follow her.

During much of this period the males are without antlers, although the pedicels are obvious. In late March antler growth begins.

The weather remains cold through March and rain and snow often fall. In April temperatures rise. Rain continues with occasional frost or snow until May or June.

SOCIAL AGGREGATIONS

The deer in the study area are not herd animals and seldom form large groups. The stable social units are small, consisting of the family group, and the small groups of bucks. Other than these all groupings are either chance or temporary. The frequency with which different associations of deer were observed in the study area is presented in Table 3.

Family groups.—The most stable social unit is the family group. This consists, at a minimum, of a doe and one fawn, and at a maximum of a doe, two fawns and two yearlings. It takes shape with the birth of the fawns in May, and is completed when the yearlings are again accepted by the doe in June and July. In some groups antagonism of the doe toward male yearlings persists, but in others they are accepted as readily as the females.

The family group remains together during summer and fall. It may be scattered under extreme disturbance, or occasionally some member may wander away temporarily, but it usually reforms and at most times has a consistent organization. The rut in late fall disrupts it. At this time the doe may leave for periods of several days to travel with bucks. From this time on there is a greater tendency for individuals to absent themselves. Yearling males and male fawns show the greatest independence, and may venture into strange situations alone.

Winter and spring bring a partial break-up of the group. Male yearlings are often the first to leave, joining with buck groups during the winter. Some male fawns leave at this time, but most remain with the mother during their second year of life. Female yearlings leave

TABLE 3.—*Associations between deer*

Season:	June–July Summer	Aug.–Sept. Hunt	Oct.–Nov. Rut	Dec.–Feb. Winter	Mar.–May Spring
No. of groups:	373	220	188	203	73
Groups	Percentage of total groups observed (1951–53)				
Adult doe with family	48	59	26	36	29
Adult doe alone or with yearling(s)	17	15	22	25	22
Yearling(s) alone	5	5	5	6	6
Fawn(s) alone	2	2	6	5	1
Adult does together in various groupings	4	2	3	4	16
Adult buck alone	8	10	18	7	6
Two adult bucks	5	3	2	6	0
Larger buck groups	4	1	1	3	7
Adult bucks with does or family groups	6	3	18	7	14

TABLE 4.—*Mobility of deer in relation to center of activity*

	Distance from center of activity in yards							
	0–250	250–500	500–750	750–1000	1000–1250	1250–1500	1500–1750	1750 plus
Adult males								
No. of sight records	126	72	29	8	2	0	0	2
Percentage	53	30	12	3	1	—	—	1
Yrlg. males								
No. of sight records	80	27	1	0	0	0	0	0
Percentage	74	25	1	—	—	—	—	—
Adult females								
No. of sight records	204	58	16	6	3	0	2	2
Percentage	72	20	6	2	1	—	1	1
All deer								
No. of sight records	410	157	46	14	4	0	2	4
Percentage	64	25	7	2	1	—	1	1

the group between mid-winter and spring when they may produce young of their own. Female fawns are most closely attached, and usually remain with the doe until driven off temporarily at the start of the new fawning period.

In Table 4 it will be noted that there is a marked decline in the number of observations of intact groups during the rut, followed by an increase in winter, and a marked decline in spring.

The persistence of the young in the family group during the first two years of life gives opportunity for them to learn much from the mother. It is likely that many activities, particularly those related to home range and migration behavior, are learned rather than inherited behavior patterns.

Buck groups.—Bucks may be seen alone or in groups of various sizes. Certain bucks have a strong tendency to associate together throughout most of the year.

In summer two or three males often travel together, although most bucks are solitary. During the hunting season some groups hold together, but the percentage of solitary bucks increases. During the rut, buck groups are least likely to form. In winter and spring the percentage of larger buck groups increases.

At any season bucks temporarily may join a family group, or lone doe, and travel together for a day or two. Associations of bucks with does are most common during the rut and in late winter and spring (Table 3). Yearling males may associate temporarily with adult bucks at any season, but form more permanent associations in the spring.

Random associations.—All types of temporary deer groups, with all combinations of sex and age classes, are sometimes found. Unusual groupings of deer occur most often during periods of disturbance, especially when young animals become separated from their family groups and seek the company of any deer in the vicinity. Such aggregations have no permanence.

Feeding groups.—At times several family groups and buck groups come together to form large feeding bands—most commonly in spring. These associations bear a superficial resemblance to a social herd, particularly if disturbance forces all to flee by the same escape route. A prolonged study of such a feeding group, however, reveals that each of the smaller units retains its integrity. Close approach of two such smaller groups often results in conflict between them. At the end of a feeding period, each group often goes its own way, without reference to the activity of the others. No permanent social aggregation is formed.

Significance of social structure.—Social groupings among deer in Lake County are similar to those described by Linsdale and Tomich (1953) for the Columbian black-tailed deer in the south-central coast ranges of California.

Thane Riney, who studied the deer of the Jawbone area of the central Sierra Nevada (Leopold, *et al.*, 1951) has stated in conversation that the migratory California mule deer (*O. h. californicus*) in this region have a similar social organization. These deer appear to form herds during migration, and on the open areas of the winter range. There is however, no true herd organization at these times. Each group retains its identity and goes its own way.

Townsend and Smith (1933) state that the family group and the small buck group are the usual social units among white-tailed deer in New York. In discussing herding they state "the white-tailed deer is to some extent a social animal, though as might be expected from the nature of its habitat in thickets and swamps, the groups are rather loose and not under present conditions large. The term 'herd' can hardly be applied to these groups unless it be at the time of yarding in the winter. Even then the term 'band' of deer seems to be a better one."

However, Palmer (1951) describing the half-tame deer of Tomhegan Camps, Maine, indicates the existence of a recognized social order above that of the family group. He describes the deer in this area as having a matriarchal organization, led by an old doe. The deer in the area were, for the most part, the fawns, yearlings and older offspring of this doe, and accepted her leadership. They could be considered as forming a loosely organized herd.

From our observations of the various subspecies of mule deer in California, and from most references to group size in *Odocoileus* in the literature, it would appear that the family group or small buck group is the normal social aggregation. There is no good evidence that herding, as described by Altmann (1953) for elk, or Darling (1937) for red deer, in which several family groups associate in a more or less permanent band with a recognized leader, occurs among the smaller North American deer. That the behavioral characteristics that could give rise to a herd organization exist in *Odocoileus* is indicated by Palmer. It may well be that studies of the social organization of the Rocky Mountain mule deer inhabiting the open sagebrush plains of the west would reveal further development in this direction. McLean (1940) in writing of the mule deer in the sagebrush areas of Modoc County, California, indicates a herd organization in stating "I did see, however, one battle between two bucks that created quite a general disturbance in the harem, even some downright quarreling. . . . Does are only fairly tolerant of each other at any season, and occasionally one will strike a lesser animal if the opportunity arises. . . . In spite of the fact that large numbers of does and fawns are often seen together, the 'bosses' are apparently well known and respected at all times." That a "harem" of does was present, with a dominance order implied, indicates a different social situation from any that we have observed.

In reviewing the literature for information on group size in other species of deer (Lydekker, 1898; Millais, 1897; Johnston, 1903; Palmer, 1926; Cabot, 1939; Darling, 1937; Phillips, 1935; A. Murie, 1944; O. Murie, 1951; Baumann, 1949; Banfield, 1954) we have found that deer that inhabit dense cover usually form small groups, or are solitary. Herds are typical of the species that inhabit open areas of grassland and tundra. The change from a small group to a herd organization is probably associated with the increased need for protection from enemies, and may also be an adaptation to the ability of the vegetation to withstand heavy grazing (Murie, 1951). That a species may change its herding habit is indicated by Cameron (1923) who states that the herding habit in the red deer of Scotland developed with the destruction of the primitive forest, and the conversion of the cover to grass and low shrub. Through detailed studies of the Rocky Mountain mule deer wintering on the sagebrush plains it may be possible to find a similar development in *Odocoileus*.

MOBILITY

The mobility of the Columbian black-tailed deer was studied primarily by observations of 88 marked individuals in the general study region. Of these 88, 60 were ear-tagged, and the others were identified by antler peculiarities or other natural markings. On the main study area there were 42 marked deer. During the period from 1950 to 1955 we accumulated about 650 sight records of the marked deer, with about 550 of these being from the study

area. A maximum of 52 observations, over a five year period, were obtained for one individual. In addition to the data from marked deer, much valuable information on movements was obtained through the daily watching of several hundred other individual deer. Some early findings on deer mobility have previously been reported (Dasmann, 1953), but subsequent data necessitate a revision of some of the earlier conclusions.

Migration.—Studies made during a statewide survey of deer populations (Longhurst, *et al.*, 1952) indicate that the deer of Lake County are similar to most of the deer inhabiting the south and central coastal area of California in lacking a distinct regular seasonal migration. True seasonal migrations are found only among the deer inhabiting the high mountains of the north coast, the Sierra Nevada and Great Basin ranges, and the high mountains of southern California. In all of these areas heavy winter snowfall forces deer to leave the higher elevations and move to winter ranges below the area of deep snow. Where heavy snow does not occur the deer are resident in one area throughout the year. An exception to this rule is the burro deer of the southeastern deserts of California. These deer are reported to migrate in response to rainfall which permits the occupancy of areas that must be deserted again in the dry part of the year (Longhurst and Chattin, 1941).

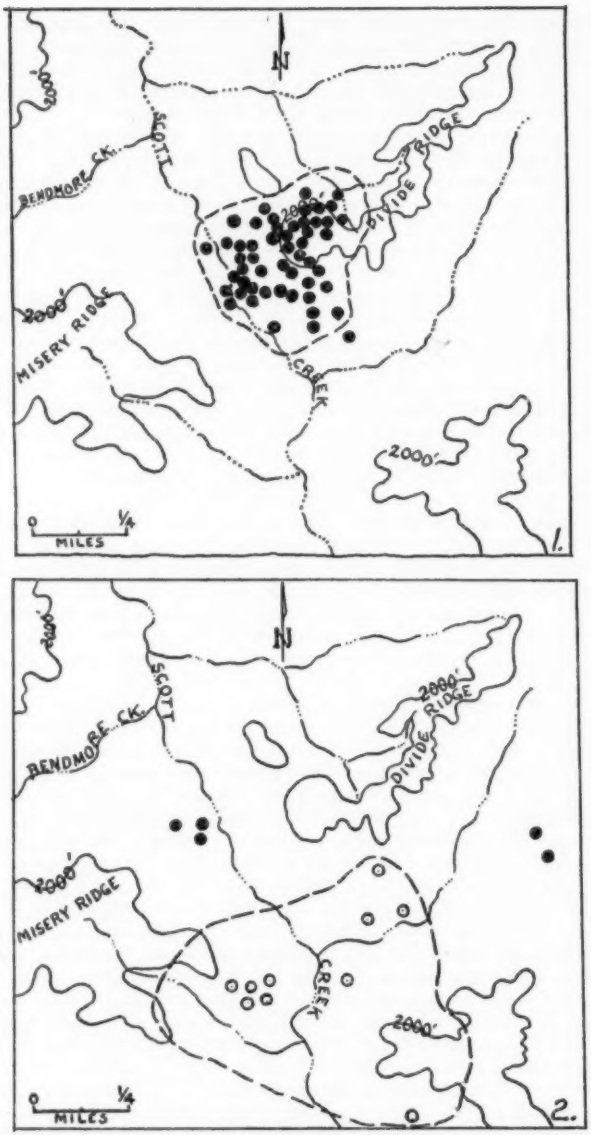
Home range.—Home range is used here in the sense defined by Burt (1943). The home range of a deer is the area normally occupied in the feeding, resting, and escape activities of the animal. It is an area within which the young are born, and in which they often remain through the first two years of life. As discussed in this paper, any area in which a deer is observed is included in its home range unless other observations provide evidence that the locality is one not normally occupied. Home ranges are irregular in outline; however, for simplicity, we refer to them in terms of their maximum diameter. In order to determine the extent of a home range, sight records of a marked deer are plotted on a topographic map and maximum diameter is measured as the greatest distance between outlying sight records. For deer observed often, the home range as delineated by this method probably includes all of the area that a deer normally uses. For deer observed less often, the total area occupied may be larger than that indicated. However, negative evidence helps in defining the home range boundaries. Areas under regular observation in which a deer is not seen can be excluded from the home range.

Within the home range is a home range center, or "center of activity" (Hayne, 1949). We have defined these centers as the central point of the area within which the animal is most frequently seen. In doing so we introduce a bias toward the feeding areas, and open bedding areas in which a deer is seen readily. Most deer had areas of preferred bedding and escape cover to which they regularly retired, but within which they could seldom be observed. The true center of activity probably lies closer to these areas of dense cover.

As discussed by Dice and Clark (1953) the distance between a point occupied by an animal and its center of activity is known as the activity radius. They conclude that although each animal has a center of activity, it has no fixed outer boundary to its range. As the distance from the center of activity increases, the probability of occurrence of an individual decreases. Our observations, however, favor the concept of home ranges limited by definite boundaries. The home range is the area with which the animal is familiar; outside is unknown territory. Although occasionally a deer will travel outside of its home range, these travels are of a different category than normal movements within the home area.

Adult does.—The average adult doe occupied a home range with a maximum diameter between 700 and 1400 yards. Among 14 well-known adult does in the study area, only one occupied a larger home range. For most does, all of the year was spent within the home range, but a few were found on rare occasions to journey beyond. An activity radius of 500 yards from the home range center will take in 92 per cent of all sight records of does in the study area, 72 per cent of all records are within a radius of 250 yards (Table 4).

There is much difference among individual does both in home range size and mobility within the home range. Doe 755, for example, for which 52 records were obtained, occupied an area with a maximum diameter of 750 yards; 74 per cent of the sight records were within an activity radius of 250 yards (Fig. 1). Outlying records occurred during the summer and



FIGS. 1, 2.— (1) Sight records of adult doe, 755. Broken line represents home range boundary. (2) Sight records of adult doe, 1325 (solid circles) and the home range of another doe (open circles) with a similar movement pattern.

rutting season. During winter she confined herself to a smaller area, centrally located on the higher ridge tops and south-facing slopes of her annual range, with a diameter of 500 yards. In summer she continued to use the wintering area, but extended her travels to places avoided during the winter. Eight other does in the study area had similar home ranges, with diameters ranging from 625 to 900 yards, and with 74 to 92 per cent of the sight records within 250 yards of the center of activity.

From the simple, compact home range of doe 755 the shapes and sizes of home ranges vary to the extreme represented by doe 1325, for whom only five sight records were available (Fig. 2). She was tagged first in October, 1952, and subsequently retrapped in late November in the same trap. After November she was searched for, but not found, until April 30, 1953, when she was located 1500 yards to the east. Here her 1953 fawns were born, and she was sighted again in June. By August, however, she had shifted back to the location of the deer trap. She apparently occupied two separate areas, one in summer and fall, the other in winter and spring. The maximum distance between sight records was one mile. The intervening region was under regular observation, so it is unlikely that she spent much time there. Her summer-fall home was on a low north slope, unsuited for winter occupancy. Other deer, however, who summered in the same area moved only a short distance up slope during the winter. Without more sight records it is impossible to say whether she had two distinct seasonal home ranges, or just a large single home range, the central portion of which was little used.

Several other does had home ranges approaching that of 1325 in size and nature, but not as extreme. These animals had summer and winter areas at least partly separate (Fig. 2). Most of the time in summer was spent on one side of the home range, most of the winter on the other side. The intervening central portion, however, was regularly used. For these animals a greater number of sight records were available.

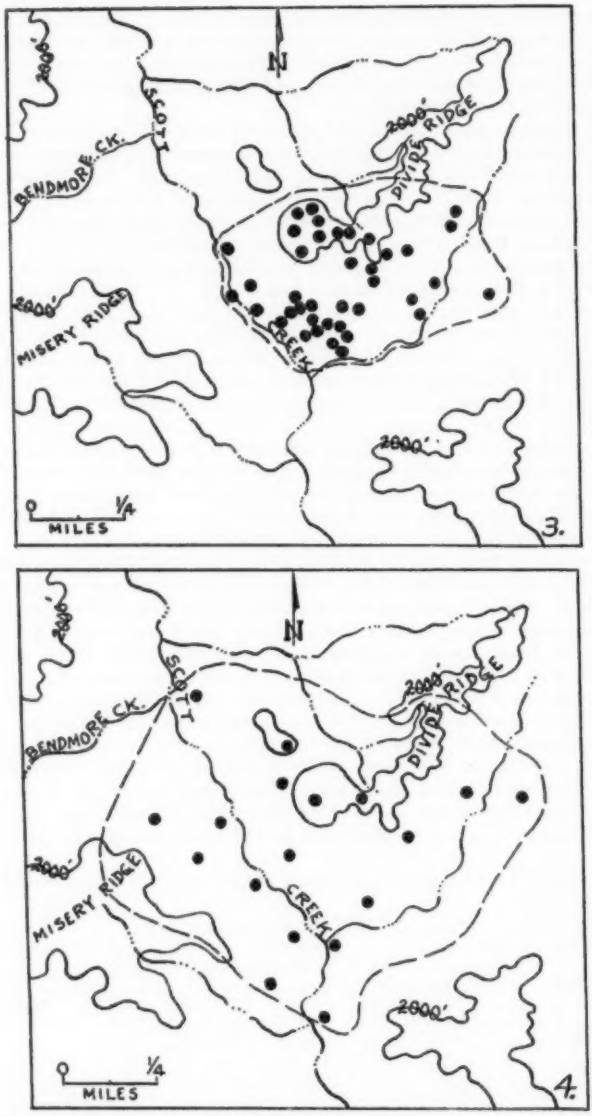
For many does the home range is contracted in winter to a smaller, favorably located wintering ground. For those does, such as 1325, where the winter and summer areas lie at opposite ends of the home range, we can see the beginnings of a migratory pattern of mobility. In the Hopland region, to the west of our study area (Longhurst and Douglas, 1953), the deer move in winter from the higher mountain tops to spend their time in a lower woodland belt. Although distances between summer and winter areas probably are not much greater than a mile, and both could be considered as part of a single home range, this may represent a further development toward a true seasonal migration. In this area the mountain top is colder and less favorable for deer in winter than the woodland belt.

Adult bucks.—Bucks were more mobile than does. Like the does they occupy home ranges, but of larger diameter. Of 15 well known bucks in the study area, only two had home ranges over 1400 yards in diameter, but a larger percentage of bucks than of does were in the 900 to 1400 yard category. Home range diameters for the better known individuals are tabulated (Table 5).

Within the home range bucks are more mobile than does. Only 53 per cent of the sight

TABLE 5.—*Diameters of home ranges*

Diameter, yards	No. of individuals (1951–1955)		
	Adult bucks	Yrlg. bucks	Adult does
0–600	1	1	1
600–800	6	5	9
800–1000	8	1	6
1000–1200	4	0	1
1200–1400	6	0	2
1400 plus	2	0	2



FIGS. 3, 4.—(3) Home range of adult buck, KB3. (4) Centers of activity of adult does, 1952–53, showing spacing. Broken line represents study area boundary.

records for bucks were within a radius of activity of 250 yards, compared to 72 per cent for does. The home range of one of the more frequently observed bucks is illustrated (Fig. 3). Bucks, like the does, show great individual variety in the size and shape of home ranges.

Young animals.—Yearling bucks resemble does rather than adult males in home range. Even those unattached to families occupy an area about equal in size to that of an average adult doe. It is not until late in their second year of life that they begin to extend their travels. Two-year-old males also are somewhat less mobile than older bucks.

Yearling females and fawns are usually attached to doe groups and their travels correspond to those of the adult. There is little evidence that adult does restrict their travels when the fawns are small. Some does may move at this time from that part of the home range used for fawning to another part used as a summer center. During early life, the fawn may not accompany the doe in foraging travels, but later its travels are the same. Adult does without fawns seem no more mobile than those with families.

Daily movements.—The daily travels of a deer within its home range may be restricted to a small area not over 100 yards across or take in the full breadth of the home range. Frequently a deer will remain for days in a small brush patch where it will both feed and bed. On other occasions after feeding briefly in one place it will move to another feeding ground across the home range. When disturbed it may travel the entire width of the home range, or head for nearby cover and run not more than a hundred yards. Usually each deer has its preferred area for escape and will head for this even though other cover, outside the home range, may be close by.

We could not study night activity directly. Observations of the same deer in late evening and early morning suggest that nocturnal travels are no longer than the diurnal. However, some deer take advantage of darkness to visit areas avoided during the day, such as places where human disturbance is frequent. Darkness may serve as cover, permitting deer to visit ground too open for daytime use.

Movements outside of the home range.—Three categories of travels beyond home range boundaries were recognized during the study. These are: rutting season travels, wanderings, and dispersal travels.

Rutting season travels.—During the rut adult bucks leave their home ranges and travel to other areas, apparently in search of receptive does. Does are also more active at this time, but usually only during or near the time of estrus. They sometimes travel beyond their home range boundaries, but the distances involved are not great.

Some bucks were observed to travel up to a mile beyond their home range boundaries, and others were thought to have travelled farther. Other bucks, however, were observed within their home ranges throughout the rut, and apparently did not travel beyond. A buck will sometimes remain away from its home range for two weeks or more, but when the rut is over will, in all cases observed, return home.

It would be interesting to know if a buck returns each rutting season to familiar ground, a situation reported for red deer by Baumann (1949), or whether it wanders freely into unfamiliar areas. It would also be valuable to know if the buck that has left the area in which it spent the first year or two of life regularly returns to it during the rut. On neither point do we have adequate data.

Wanderings.—At seasons other than the rut some deer were found far outside their home range boundaries. Doe 799, tagged in October, 1950, was seen in the winter of 1950–51 in an area two miles from the trap. The next summer she was retrapped in the same trap, and was seen regularly thereafter in a home range with a diameter of 700 yards. Another doe, 1322, was trapped three times in the same trap in November, and December, 1952, and subsequently observed in the immediate area. The following February she was found dead 3½ miles away. In summer, 1951, an unidentified tagged doe was seen 2½ miles from the nearest trap. Several other does were also observed at lesser distances beyond their home range boundaries.

Among bucks similar wandering movement occurred. One buck, normally observed in an area with a diameter of 600 yards, travelled on one occasion 2000 yards from this home range

boundary, and subsequently returned to it. Another buck was observed at widely spaced locations up to 2200 yards apart. For him we could find no definite home range or activity center.

Wandering was thus not restricted to either sex or to any one season. It occurred most often in older deer. It cannot be categorized as migration, dispersal, nor travel in search of some particular food. In some instances it may represent emigration, but in others a return to the home range takes place. The spectacular nature of these wanderings leads to an over-emphasis. Table 4 indicates that only a small percentage of the population is affected. The bulk of the population remains throughout the year within a restricted home range.

Dispersal.—The records of marked deer yielded no positive evidence that young deer dispersed to new areas. In the few instances where the yearlings could be traced from one year to the next it was found that they occupied areas close to and overlapping the area occupied with the family group.

Indirect evidence, however, indicates dispersal. In the spring of 1953, many young deer disappeared from the population of the study area. It is fairly certain that they did not die. The population structure at the start of the intensive study in 1951 indicated that a movement of young deer into the area must have previously occurred. Prior to 1951 the area was one of the most favorable for deer in the whole region, a result of the 1949 fire. By 1953 the area was much less favorable since the forage quality had declined.

During the entire 1952–53 season a different pattern of deer activity was observed than was seen in 1951–52. There was less tendency for the deer to feed in the central part of the study areas, and more tendency to feed in the periphery. Some individual deer were known to extend their home range boundaries peripherally. It is likely that the apparent dispersal of young deer in 1953 actually reflects a drift of many deer away from the previously preferred feeding grounds, and not an emigration movement involving travel for any considerable distance.

It may be postulated that in 1949 deer were well distributed over the entire region, although not as numerous as in later years. The 1949 fire created an area of excellent forage in the middle of the study area. Deer whose home ranges touched this central area, began to spend the greater part of their time feeding there, and may have extended their home range boundaries to take in more of the burned area. Later, with the decline in forage quality, the central area that lacked escape cover held no further attraction for deer. They distributed their time more equally over their entire home ranges, and perhaps extended these to take in new peripheral feeding grounds. Hence, they were less frequently observed within the study area and in some cases missed in the population tallies. Subsequent observations in 1954 and 1955 indicate that this was most probable.

It is likely that some young deer in this region move long distances to set up new home ranges in distant areas. We were unable to detect this movement. Those young deer that we could recognize stayed near their birthplace. It is likely that the normal method of population spread into new habitat, for these deer, is one of slow diffusion (Heape, 1931) rather than rapid emigration.

Comparisons with other areas.—Detailed studies of deer movement have been carried out in California during the Jawbone herd study by Riney (1950), and on the Hastings Reservation by Linsdale and Tomich (1953). The results of these studies are generally in agreement with ours. In the Jawbone area deer were found to have separate small home ranges in winter and summer, and to follow regular migration routes between them. Other than dispersal of young, movements outside of restricted home range boundaries during either winter or summer were not observed. The summer home range was larger than the winter. At Hastings Reservation, where deer are resident, the movements recorded were similar to what we have found.

Zwickel, *et al.* (1953), reporting on movement of the Columbian black-tailed deer in Washington, find a normal tendency for does, fawns and young deer to confine their movements within restricted home ranges, the size of which may be up to 1.25 miles in diameter. Adult bucks engage in long distance travels during the rutting season. Snowfall in the win-

ter results in longer migratory movements to winter ranges. What were presumed to be rutting season travels in adult bucks carried them up to 16 miles from the trapping sites, much farther than any we recorded in Lake County. Dispersal of young deer was observed, with a yearling buck travelling 11 miles, and a two-year-old buck travelling 19 miles. A doe fawn, subjected to harassment from a herd of semi-tame deer, travelled six miles to a new area. Captured and returned to the herd, she again visited this new area on two different occasions.

The Washington studies agree with our findings: that most deer remain in relatively restricted home ranges, that most young deer do not disperse long distances, that a few deer engage in either long emigrations, or distant wanderings with a subsequent return to the home ground.

Stoddart and Rasmussen (1945) studied deer migration in Utah by the use of tagged deer. They found that deer do "extremely little migrating to new areas, but prefer to spend their life in the drainages where they are born." Their findings are corroborated by Leopold, *et al.* (1950) who found that migratory deer return year after year to the same winter and summer home ranges.

Einarsen (1946) states that in the Tillamook burn in Oregon, the blacktail deer seldom migrate long distances, but remain in a small area throughout the year, changing habitat only when forced by persecution or adverse weather. He states that deer moved into the burned area from adjacent areas of poor forage, but did not determine the distances traveled.

In Yellowstone, Murie (1940) found that deer occupy restricted home areas on the winter ranges, not more than a mile across.

In southern California chaparral areas, Cronemiller and Bartholemew (1950) report that resident deer occupy small home ranges.

Exceptions to the usual pattern are from areas such as that occupied by the Devil's Garden herd of California and Oregon (Interstate Deer Herd Committee, 1947). Here the area occupied in winter varies from year to year with the severity of the weather. It is difficult to see how each deer can be said to have a small winter home range which is regularly occupied. Each deer must have either several possible winter home ranges, or else no fixed winter home range. The situation in summer is not reported.

Another exception is the report by Bryant (1924) that a belled doe in Yosemite occupied four separate areas during four successive summers, with a distance between these areas being a maximum of 17 miles. It wintered each year at the place where the first summer was spent. Considering that the Yosemite area is generally similar to that used by the Jawbone deer herd, it seems probably that the behavior of this one deer is exceptional.

Among white-tailed deer most reports indicate that movement is similar to that of mule deer. In the Edward's Plateau of Texas, Hahn and Taylor (1950) found the deer to be nonmigratory, and to occupy restricted home ranges. Most sight records of deer were within the square mile in which the traps were located. A few deer were known to travel longer distances, with the maximum being seven miles for a buck.

Palmer (1951) reports that the deer of Tomhegan Camps, Maine, usually remain in a small, restricted area. Some individuals, particularly bucks, were either driven away, or moved voluntarily to different areas. Antagonism between deer apparently caused most of the dispersal.

Townsend and Smith (1933) and Spiker (1933) report that deer in New York occupy restricted home areas in summer. In the winter severe snows force them to winter yards where they are again confined to a small home area. In open winters they remain on the summering grounds. In one winter yard the same individuals were known to return year after year.

Olsen (1938) states that white-tailed deer trapped in winter yards in Minnesota migrated in summer up to a maximum of 13 miles for bucks, and five miles for does. Retrap records indicated that deer returned to the same yard in successive winters. Results from Michigan reported by Bartlett (1950) are similar.

Thus, the literature on *Odocoileus* in North America indicates that the situation in

Lake County among black-tailed deer is probably typical of non-migratory deer of this genus. The usual tendency is for the deer to occupy home ranges, perhaps up to 1.5 miles in diameter. In these home ranges the adult does and young deer remain throughout the year, and perhaps throughout most of their lives. Adult bucks have larger home ranges than does, in which they remain except during the rutting season, at which time some of them travel many miles in search of does. The position of the home range may shift slightly from year to year to take advantage of improved habitat conditions. Many of the young deer will settle on or near the area in which they were reared. Some, however, may be driven away by older deer, or may leave for other reasons and travel many miles before establishing a new home range.

Migratory deer probably occupy summer home ranges similar to those of resident deer. In winter they move either to a winter yarding ground or in mountainous country to a winter range below the snow belt. Where migrations are regularly forced by weather, and the same wintering ground is used year after year, the migratory deer may establish a secondary winter home range. If this is done they will regularly travel between their two home range areas.

Some deer may always prove to be exceptional and somewhat nomadic in habits, wandering from a home range to new grounds without apparent reason, or making long journeys away from their home area with a subsequent return. Individuals may fail to regularly return to the same wintering ground, or summer area. Most deer, however, seem fixed in their habits and remain on familiar home ground throughout life.

Factors influencing deer movements.—The home range of a deer must contain those elements of food, cover and water essential to the welfare of the animal. The distribution of these elements within a given habitat probably determines the size of the home range (Riney, 1950). Movements within the home range are influenced by daily and seasonal changes in the quantity and quality of the requirements for life and well-being. Once a pattern of movements is established it is usually maintained. A home range map is necessarily generalized. Actually a home range consists of series of small feeding, bedding, watering and escape areas connected by travel lanes familiar to the deer. The home range is familiar ground, and within it the deer moves freely.

Assuming that most deer maintain home ranges, the factors that cause a deer to leave a home range become of importance. Studies of deer migration (Dixon, 1934, Russell, 1932, Riney, 1950) indicate that seasonal unavailability of food is the principal factor that forces a deer to leave its summer range. In high mountains the depth of snow is usually sufficient to cover the forage, and to prevent deer from moving freely about. During mild winters, with little snow, many deer winter high on their summer ranges. The return spring migration from winter to summer range cannot be readily interpreted in terms of forage availability. Green herbs and new brush sprouts grow on winter ranges as well as summer ranges. Perhaps the spring migration should be regarded as a return to a preferred, and traditional home area in which the young are born and reared, which winter snow had previously prevented. If this be true the spring movement can be termed a gametic migration, as compared with the downward alimental migration of autumn (Heape, 1931).

There are some deer populations in California that leave their summer ranges well in advance of deep snow and proceed toward their winter ranges. In other populations, some of the deer will migrate regardless of weather conditions that permit continued occupancy of the summer range. To some extent, then, migration must be traditional in a deer population, and not in every year determined by the unavailability of forage. However, the primary cause of the fall migration is snowfall. Those deer that in mild winters tarry on summer ranges are sometimes trapped by sudden, severe snowstorms.

In the study area winter snowfall does not force migrations. Food remains available through the winter. Deer shift within familiar home areas to improve their food supply but are not forced to leave their home ranges.

Movements of deer to feed in orchards regularly occur in Lake County, and elsewhere in California. Deer from the study area would have to travel two miles to reach the main

orchard belt. If such travels took place they were so rare that they were not detected. To check on the distances a deer would travel to feed in an orchard we watched deer from observation posts, and made morning and evening track counts along roads. It was found that the deer involved in orchard damage were those whose normal home ranges included part of the orchard belt. With some possible exceptions, other deer did not extend their travels to take advantage of the qualitatively superior orchard forage, even when they were unable to obtain adequate nutrition in their home areas.

The effects of chaparral burns on deer movement were also studied. Burns located at 1000 yards, and 500 yards from the study area boundary, and within one edge of the study area were available for study. The sprouting brush in these burns would have provided palatable and nutritious forage for the deer of the study area during periods when other available forage was inadequate. However, the burns did not attract deer to leave their established home ranges. Deer remained in their home areas and died of malnutrition when a short journey outside would have brought them to adequate food supplies.

We may conclude that a quantitative lack of forage, such as is caused by winter snows or destruction of the vegetation by fire, will force deer from a home range. However qualitatively superior forage will not attract deer to new areas, perhaps because they have no way of knowing of its presence. As long as deer can fill their paunches with some type of food, however lacking in nutrient quality it may be, they will not travel to an unknown area to improve their lot.

We found no evidence that hunting or other disturbances would drive deer from their home ranges. Actually intensive hunting seems to restrict the mobility of deer. They find good cover and hide there. We have attempted to drive deer from their home ranges, using dogs, but were unable to do so. Similar attempts by Riney (1950) in the Jawbone area were also unsuccessful. The situation may differ however where cover is less adequate. In the Hopland area to the west of Lake County, Longhurst (Ms) reports that hunting pressure in public land on the mountain tops forces the deer to move down into the protected lower woodland grass belt. There are similar reports from various areas of deer moving into refuges as a result of hunting pressure. There is no evidence, however, that these are not movements within familiar home ranges.

DOMINANCE, AGGRESSION AND TERRITORIALITY

The existence of dominance hierarchies was generally noted within deer groups in the study area. Further observations of deer held in captivity at Yountville, California, indicated that a definite "peck-order" develops whenever a number of deer are brought into close association. Kabat, *et al.* (1953) have described similar behavior in the white-tailed deer. Dominance relationships may also exist between those deer groups in the wild that occupy adjoining areas, but this has not been ascertained.

Aggression.—Aggressive behavior in deer is manifested in several ways. Most commonly observed is a threatening demeanor, perhaps accompanied by a discharge from the scent glands (Nichol, 1938). This usually leads to the retreat of the threatened animal. Less common are foot striking, or actual combats involving flailing with the front feet. Aggression between bucks during the rut may involve antler combats, and is perhaps as much a means of sexual stimulation as a test of dominance (Darling, 1937). Aggressive behavior of the foot-striking variety is manifested by both sexes and all ages of deer.

Dominance.—Aggressive behavior within the family group occurs most often during spring and summer as aggression of the adult doe toward her yearlings. Less commonly seen is aggression of yearlings toward fawns, or of one fawn toward another. The leadership of the adult doe is not challenged within the family, and actual conflicts do not occur. The older deer exhibits leadership in many ways. In travelling across ridges, or to new feeding grounds, or into any strange situation, the adult doe goes first and investigates. Often yearlings and fawns will not flee from a suspected danger which they have first detected until the adult doe has been alerted and takes action. However, at other times, when the danger is more obvious or imminent, there may be no precedence in departure.

In buck groups dominance conflicts are common, particularly in early winter when the larger buck groups are forming after the rut. At this time nearly every meeting between bucks brings conflict, involving threats and foot-striking. Usually the dominant position is taken by the oldest and largest male. Within the buck group, however, there is little coordination. The dominant buck does not exhibit leadership in the manner of the adult doe. In the event of alarm the first buck to detect danger may flee without alerting the other members of the group. The group does not necessarily hold together in common flight.

In feeding groups during the winter, and at all times during the rutting season, the adult bucks are clearly dominant over does. During the summer and fall, aggression between adult bucks and adult does was not observed.

Considering the restricted mobility of the deer, and the observed tendency for the young to remain near the area in which they were reared, it seems likely that many of the deer in the study area are close relatives, and that the older does may be the mothers of younger ones occupying nearby home ranges. If so, it is likely that a definite social hierarchy exists throughout the population of a small area, much as was found by Palmer (1951) for the Tomhegan Camps deer. However, we were unable to verify this.

Spacing and territoriality.—If the centers of activity for adult does are plotted it is found that these are relatively evenly spaced through the study area, and that each is separated from the others by at least one hundred and usually 150 or more yards (Fig. 4). This spacing appears more regular than would be true if the distribution of the home range centers were random.

The principal reason for this spacing appears to be mutual antagonism between adult does. It will be noted from Table 3 that at most seasons of the year adult does are seldom found together. When they do come into close contact, conflicts are frequent although not invariable. These occasional conflicts may be remembered by the does, and cause one doe to avoid the area occupied by another. Other behavior, perhaps involving scent, may also be involved in this mutual avoidance.

Evidence that memory or habit may be involved is illustrated by certain adult does that died during the heavy mortality of 1951–52. The centers of activity previously occupied by these deer continued to be avoided by neighboring does in the absence, not only of intimidation display, but of the original does themselves.

The tendency for one doe to avoid another, and for each to spend its time well apart from the others results in spacing ecologically similar to what would be found if the home range centers were actually defended territories.

It will be noted in Table 3 that the frequency of association between adult does increases in late winter and spring. At this time many does have lost their fawns through mortality, and in other groups family ties are less strong. Territorial behavior thus tends to disappear as the need for actively caring for the young decreases, and the does become more gregarious. With the birth of the new fawns, antagonism between does again results in spacing.

If the centers of activity for bucks are plotted a tendency toward aggregation is found. No aggressive behavior, other than peck-order behavior and sexual aggressiveness, was observed. These conflicts had no obvious effect upon population spacing. It may be that between larger groups of bucks a degree of spacing occurs. In the region of study the bucks could be divided into separate populations that rarely contact each other, except during the rut. It is possible, but remains unproven, that bucks from one population will not tolerate the presence of bucks from other populations.

We know of no studies of territorialism in *Odocoileus*. Linsdale and Tomich (1953) do not discuss territoriality as such, but indicate that adult does tend to keep clear of each other, and that few occasions for irritation arise between them.

Deer inhabitating areas of sparse cover, or feeding in open areas away from cover, form larger, more compact groups than do the deer in the study area. It may be that under these conditions a greater tolerance between individuals may develop. In our observations, however, such large feeding groups form during winter and early spring, when territorial behavior would be at a minimum. It may be that these deer also exhibit, among does, mutual intolerance on the summer ranges when the fawns are young.

DEER BEHAVIOR AND POPULATION DENSITY

Several elements of deer behavior were found to be influenced by and perhaps to have an influence upon population density. It seems possible that a density level may exist beyond which intraspecific intolerance will not permit the population to increase. Observations during the summer and fall of two years of different population density, 1951–52, when 90 deer were on the study area, and 1952–53, when the population was 72, are used for comparisons.

Home range size.—Home range diameters of tagged deer were larger in 1952–53 than they were in 1951–52. For some individuals actual home range extensions were observed. The mobility within home ranges also increased in 1952–53, with deer spending less time near their centers of activity. It might be concluded that with the decrease in population density, deer expanded their home ranges to take advantage of the additional area. However, another explanation is possible: that the apparent increase in home range size is caused in part by a peripheral shift in the home range, described previously, and in part by the greater number of observations of marked deer that were obtained in 1952–53. It seems likely that home ranges that are not mutually exclusive are determined in size by the habitat, and not influenced by density.

Territorialism.—The existence of territorial behavior in deer has an obvious effect on population density. We cannot state the extent to which centers of activity of adult does may be crowded together within a given area. At some point, however, crowding will result in an intolerable increase in conflict and aggression. At this point we should expect either dispersal or mortality to occur. The excessive mortality of 1951–52 occurred when population density was at a maximum. Malnutrition was the obvious cause, however intraspecific strife may have accentuated the die-off.

Aggression.—In 1951–52, there were more contacts between individual deer. With this increase in contacts, the frequency of aggression also increased. Both the number of contacts and the number of conflicts indicated greater activity and greater irritability among deer at a higher population level.

Conflicts within groups were more frequent in 1951–52 than in 1952–53. When the density was lower, and the food supply most adequate, there was a minimum of friction within the family group. Conflicts between groups showed a similar relation to density. With a decrease in population density there were not only fewer contacts between deer groups, but also fewer conflicts in an equal number of contacts. Tolerance of one group for another therefore increased as density decreased and food became more abundant.

Alarm behavior and play.—Altmann (1953) found that elk on poor range have a much greater "object-flight distance" than elk on good range. She also found the incidence of play lower among elk in poor condition than among elk on good range. In the present study similar relationships were observed.

Most instances of alarm flight in deer could be related to the disturbing cause. We did not measure "object-flight distance". On many occasions, however, deer fled without apparent reason, or fled wildly when the cause of alarm was minor. On other occasions a "chain-reaction" alarm was observed, where one deer would alert another until finally many groups of deer were fleeing without reference to the original disturbance. These two categories of alarm behavior were related to population density.

In 1951–52, with higher density, there were more unexplained alerts and chain-reaction flights than in the following year. The increase in the frequency of unnecessary flights indicated a greater irritability associated with high density and inadequate nutrition.

Observations of certain individual does suggest that the nervous animals, quick to flee from minor alarms, are least successful in raising fawns to maturity. The most successful mother, which raised twin fawns to maturity in successive years, was least prone to unnecessary expenditure of energy.

Play in deer decreased as density increased. Play usually takes the form of active scampering and jumping about on the part of an individual, or games of chasing and "tag" involving two or more deer. It is most frequently observed during the early months of a

fawn's life, at which times yearlings and sometimes adult does may join in fawn play. Play probably indicates an excess of energy. In the critical forage year of 1951–52, when density was at its peak, play among fawns was at a minimum. It was higher in the more favorable forage year of 1952–53 when the density was lower.

Riney (1954) discusses increased irritability of deer as a symptom of starvation. This irritability may have the effect of decreasing crowding on feeding areas. It is not possible in this study to separate the effects of increased density from those of decreased food supply. In the wild as density increases food usually becomes less adequate. Nevertheless, it is apparent that an increase in population density brings an increase in strife and alarm behavior among deer. This puts an increased demand on the deer's energy at a time when the food is least adequate to supply it. In the absence of this increased energy output the deer could perhaps survive with a lower level of nutrition. Density-dependent behavior thus may set a lower limit to the population that can be sustained than would be set by the forage alone.

ACKNOWLEDGMENTS

Much of the field work of this study was carried out as part of Federal Aid to Wildlife Restoration Project, California W-31R. Detailed studies of movement and behavior were carried out by the senior author in the period 1952–53 with the aid of a fellowship from the National Science Foundation. Much of the material in this report was presented by the senior author as part of a doctoral thesis in zoology at the University of California.

Many individuals contributed to the work of this study. In particular we wish to acknowledge the technical advice and editorial assistance provided by A. Starker Leopold, F. A. Pitelka, and H. H. Biswell of the University of California, and the field assistance given by Bonnar Blong, Herbert Hagen and Norman Allstot of the Calif. Department of Fish and Game. The land on which the study was conducted was made available to us by Glen Keithley and Harold Manley of Lakeport, California. For all of this aid we are sincerely appreciative.

SUMMARY

Studies of those elements of the behavior of the Columbian black-tailed deer important to population ecology were carried out in Lake County, California, during 1948 to 1955. Particular attention was given to mobility, group structure, aggression and territorial behavior, and to other density-related behavioral aspects.

The deer were non-migratory and tended to occupy restricted home ranges throughout the year. Movements beyond home range boundaries were infrequent, and consisted of rutting season travels, wandering and dispersal. Deer could not be driven from their home ranges, nor did they leave them to seek qualitatively superior forage.

The stable social aggregations of deer were the family group and buck groups. Particularly in winter and spring larger feeding bands would form temporarily. However the deer were not herd animals.

Adult does were found to be mutually intolerant during the period when the fawns were young. Centers of activity of adult does were spaced well apart, much as if they were defended territories. Aggression between does was a factor causing one adult to avoid the activity center of another. Among bucks no such spacing was found.

Aggression, alarm behavior and play were all related to population density. When density was higher there was more strife and alarm flight and less play.

Territorialism and density-dependent behavior may prevent populations from increasing to the maximum that the food supply might otherwise sustain.

LITERATURE CITED

ALTMANN, MARGARET. 1953. Social behavior of elk, *Cervus canadensis nelsoni*, in the Jackson Hole area of Wyoming. Behaviour, 4: 116–143.

BANFIELD, A. W. F. 1954. Preliminary investigation of the barren-ground caribou, part II. Canadian Wildlife Service, Wildlife Mgt. Bul., Series I, 10B. 112 p.

BARTLETT, I. H. 1950. Michigan deer. Game Div. Michigan Dept. Conservation. 50 p.

BAUMANN, F. 1949. Die Frielebenden Saugetiere der Schweiz. Hans Huber, Bern. 492 p.

BRYANT, H. C. 1924. The range of an individual deer. Jour. Mamm., 5: 201–202.

BURT, W. H. 1943. Territoriality and home range concepts as applied to mammals. Jour. Mamm., 24: 346–352.

CABOT, H. 1939. Hunting the woodland caribou. North American Big Game (A. Ely, H. E. Anthony and R. R. M. Carpenter, editors) Scribners, New York: 254–261.

CAMERON, A. G. 1923. The wild red deer of Scotland. Wm. Blackwood and Sons, Edinburgh and London. 298 p.

COOPER, W. S. 1922. The broad-sclerophyll vegetation of California. Carnegie Inst. Washington, No. 319.

CRONEMILLER, F. P. AND P. S. BARTHOLEMEW. 1950. The California mule deer in chaparral forests. California Fish and Game, 36: 343–366.

DARLING, F. F. 1937. A herd of red deer. Oxford Univ. Press, London. 215 p.

DASMANN, R. F. 1953. Factors influencing movement of non-migratory deer. Proc. 33rd Annual Conf. of Western Assn. of State Game and Fish Commissioners: 112–116.

DASMANN, R. F. AND R. D. TABER. 1955*a*. A comparison of four deer census methods. California Fish and Game, 41: 225–228.

———. 1956. Determining structure in Columbian black-tailed deer populations. Jour. Wildlife Mgt., in press.

DICE, L. R. AND P. J. CLARK. 1953. The statistical concept of home range as applied to recapture radius of the deer mouse (*Peromyscus*) Contrib. Univ. Michigan Lab. of Vert. Biol., 62: 1–15.

DIXON, J. 1934. A study of the life history and food habits of mule deer in California. California Fish and Game, 20: 6–144.

EINARSEN, A. S. 1946. The management of black-tailed deer. Jour. Wildlife Mgt., 10: 54–59.

HAHN, H. C. AND W. P. TAYLOR. 1950. Deer movement in the Edwards Plateau. Texas Game and Fish, November: 1–8.

HAYNE, D. W. 1949. Calculation of size of home range. Jour. Mamm., 30: 1–18.

HEAPE, W. 1931. Emigration, migration and nomadism. W. Heffer and Sons Ltd., Cambridge, 369 p.

INTERSTATE DEER HERD COMMITTEE. 1947. Second progress report on the cooperative study of the interstate deer herd and its range. California Fish and Game, 33: 287–314.

JOHNSTON, H. 1903. British mammals. Woburn Library, Hutchinson and Co., London, 405 p.

JONES, F. 1954. The Inyo-Sierra deer herds. A final report. California Dept. of Fish and Game, 84 p. (mimeo.).

KABAT, C., N. E. COLLIAS AND R. C. GUETTINGER. 1953. Some winter habits of white-tailed deer and the development of census methods in the Flag yard of northern Wisconsin. Wisconsin Cons. Dept., Tech. Wildlife Bul. 7. 32 p.

LEOPOLD, A. S., T. RINEY, R. MCCAIN AND L. TEVIS, JR. 1951. The Jawbone deer herd. California Div. of Fish and Game, Game Bul. 4. 139 p.

LINSDALE, J. AND Q. P. TOMICH. 1953. A herd of mule deer. Univ. of California Press, Berkeley and Los Angeles. 567 p.

LONGHURST, W. M. AND J. E. CHATTIN. 1941. The burro deer. California Fish and Game, 27: 2–12.

LONGHURST, W. M., A. S. LEOPOLD AND R. F. DASMANN. 1952. A survey of California deer herds, their ranges and management problems. California Dept. of Fish and Game, Game Bul. 6. 136 p.

LONGHURST, W. M. AND J. R. DOUGLAS. 1953. Parasite interrelationships of domestic sheep and Columbian black-tailed deer. Trans. 18th N. Amer. Wildlife Conf. 168–187.

MCLEAN, D. 1940. The deer of California with particular reference to the Rocky Mountain mule deer. California Fish and Game, 26: 139–166.

MATTHEWS, L. H. 1952. British mammals. Collins, London, 410 p.

MILLAIS, J. G. 1897. British deer and their horns. Henry Sotheran and Co., London. 224 p.

LYDEKKER, R. 1898. The deer of all lands. Rowland Ward, London. 329 p.

MURIE, A. 1940. The ecology of the coyote in the Yellowstone. U. S. Dept. Interior, Nat. Park Service, Fauna of National Parks of the U. S., Bul. 4. 206 p.

———. 1944. The wolves of Mount McKinley. U. S. Dept. Interior, National Park Service, Fauna of National Parks of the U. S., Series 5. 238 p.

MURIE, O. J. 1951. The elk of North America. Stackpole, Harrisburg, Pa. and Wildlife Management Inst., Washington, 376 p.

NICHOL, A. A. 1938. Experimental feeding of deer. Univ. of Arizona Coll. Agric., Agric. Exp. Sta. Tech. Bull. 75. 39 p.

OLSEN, H. 1938. Deer tagging and population studies in Minnesota. Trans. 3rd N Amer. Wildlife Conf.: 280–286.

PALMER, L. J. 1926. Progress of reindeer grazing investigations in Alaska. U. S. Dept. Agric. Bul. 1423. 37 p.

PALMER, R. S. 1951. The whitetail deer of Tomhegan Camps, Maine with added notes on fecundity. Jour. Mamm., 32: 267–281.

PHILLIPS, W. W. A. 1935. Manual of the mammals of Ceylon. Ceylon Jour. Science, Dulau and Co. Ltd., London. 360 p.

RINEY, T. 1950. Home range and seasonal movement in a Sierra deer herd. Thesis. M.A., Univ. of California Library, Berkeley. 42 p.

RINEY, T. 1954. Evaluating condition of free-ranging red deer (*Cervus elaphus*) with special reference to New Zealand. New Zealand Jour. of Sci. and Tech., 36: 429–463.

RUSSELL, C. P. 1932. Seasonal migration of mule deer. Ecol. Monog., 2: 1–46.

SPIKER, C. I. 1933. Some late winter and early spring observations on the white-tailed deer of the Adirondacks. Roosevelt Wildlife Bul. 6: 327–385.

STODDART, L. A. AND D. I. RASMUSSEN. 1945. Big game—range livestock competition on winter ranges. Trans. 10th N. Amer. Wildlife Conf.: 251–256.

TOWNSEND, M. T. AND M. W. SMITH. 1933. The white-tailed deer of the Adirondacks. Roosevelt Wildlife Bul. 6: 161–326.

ZWICKEL, F. G. JONES AND H. BRENT. 1953. Movement of Columbian black-tailed deer in the Willapa Hills Area, Washington. The Murrelet, 34: 41–46.

Game Management, Humboldt State College, Arcata, California, and School of Forestry, University of California, Berkeley. *Received July 29, 1955.* [Contribution from: Museum of Vertebrate Zoology, Univ. of California, and Federal Aid in Wildlife Restoration Project W-31-R.]

TERRITORIALISM IN DEER

By William Graf

Territory, as here used, is meant to include an area or range exclusively occupied by an individual or group of individuals of a species, which is defined and recognized by them as their exclusive property or territory. Such a territory may be actively defended against invasion by others outside the territory of the individual group. Where not defended, the territory is nevertheless definitely marked by recognizable "sign posts" on the territory.

What is perhaps more significant in regard to these sign posts is not so much the recognition of the territory by the animal or animals making the sign posts as the psychological effect that these sign posts have on non-members of the territory by an intimidation of the stranger entering such an occupied territory.

Darling's (1937) explanation that home range is physiological and that territory is psychological is an attractively simple definition. However I doubt that it can be as simple and clear cut as this, and the author himself would probably be the first to admit that it would be extremely difficult to separate the physiological factors from the psychological factors that enter into the determination of either home range or territorial behaviorism. Territories are usually the direct or indirect result of breeding requirements or food needs or both. Territorialistic behavior is usually developed in direct relation to the social development of the animal, the greater the social development the greater the degree of territorialistic behavior.

The sedentary habits and the tendency to occupy a well-defined home range is well recognized and generally understood in members of the Family Cervidae. Territorialism, on the other hand, apparently has been overlooked, or is not recognized in this group by most workers. Flerov (1952) and Kaplanov (1948) all give excellent descriptions of the rutting and general behavior of the various members of central European and Asiatic Cervidae. None of these writers, however, indicate a recognition of territorialistic behavior in the activities of the animals described. Heck (1935) likewise gives an excellent account of the life and habits of the European red deer (*Cervus elaphus*) but omits any mention of territorialism in this species. Darling (1937) is the only writer who seems to recognize some territorialistic significance in the behavior of deer in his excellent account of the red deer in the Scottish Highlands. His account and reference to territorialism is, however, very general and there is nothing to indicate the occurrence or the recognition of a behaviorism that has the specific significance in relation to territorialism that is indicated here.

A study of some of the social habits and behaviorisms of the Roosevelt elk *Cervus canadensis roosevelti* (Graf, 1955) has led me to the consideration that not only does this species exhibit a high order of territorialism in parts of its geographic range, but that there are indications of territorialism in other members of North American deer which up to this time have either been overlooked or have been misinterpreted by the observers.

Territorialism manifests itself not only in the antagonistic behavior of the occupant of a territory toward other members of the species, but in the highest form of development takes on the form of activities that will mark off and identify the territory in the absence of the rightful occupant. An indication of the degree of territorialism of a group of animals may be indicated by the elaborateness and ritualistic behavior of the animals in establishing the sign posts within their territory. This characteristic is perhaps more highly developed in the Roosevelt elk than in any other member of the deer family. The possible exception may be the European red deer though there is nothing in the literature at present that indicates anything approaching the degree of territorialistic behavior of the Roosevelt elk.

Herds of this species are usually family groups and are very closely knit, again more so than any other species, with possibly the exception of the European red deer. The Roosevelt elk, like the European red deer that is a product of the heavily forested regions of central and western Europe, is a product of the dense coniferous forests of the northwest coastal regions of North America. It is my belief that it is this forest relationship that has influenced the evolution of the highly territorialistic behavior of this species.

Although the "sign post" behaviorism has been described in an earlier publication (Graf, 1955), its significance was no more than suggested at that time. Evidence of this behaviorism may be seen on trails and particularly on the loafing resting grounds within the territory of the herd. It is here that the cows and female calves indulge in this activity, which may take place at any time of the year. Young and subadult bulls apparently do not indulge in this type of activity. For the cows, this activity consists of a highly ritualized pattern of behavior, starting with the careful "nosing" of a sapling or limb chosen for this operation. The nosing consists of carefully drawing the nose up and down the "post" as though sniffing it. This may be repeated a half dozen times, more or less. The second step is to scrape the "post" with the incisors, by drawing them in deliberate vertical strokes from bottom to top of the marked spot on the post and letting the shavings that result from this action, fall to the ground. Shavings are never taken into the mouth and may accumulate in quantity around much-used posts. The third step is to carefully rub the sides of the muzzle and chin on the scraped post by deliberate forward horizontal strokes of the head. The fourth step is to rub the sides of muzzle and chin against the flanks, again in the same careful and deliberate manner as in the previous steps. The order of procedure is invariably the same except that the flank rubbing or "preening" is sometimes skipped. The entire series of actions may be repeated over a period of 5 to 15 minutes.

Adult males, that is those five years or older, with a harem have been observed to perform this same behaviorism only during the rut and with the following variation: Instead of the incisors, the base of the antler or bur is used for the scraping act and this scraping act is always the first step rather than the nosing as with the cows. The scraping is then followed by "nosing" the scraped part of the post. This is performed in the same manner as by the cows, and this is

followed by the rubbing of the sides of the face and chin on the flank in the same manner and order as in the cows. The nosing, particularly, is performed with great delicacy and unhurried precision. Immature bulls under five years old without harems have never been observed in this behaviorism either outside of the herd during the rut, or in a herd between rutting seasons.

Such territorial marking may serve to locate the closely knit family groups in the event of separation of members from the group, a situation that develops not uncommonly. While combativeness between members of adjacent territories has not been observed, such sign posts may serve by intimidating strangers entering such a marked territory. The psychological effect of such sign posts in the rutting behavior of mature bulls may be of greatest significance not only in holding a harem but in avoiding a great deal of annoying attendance by outrider bulls during the rut. This significance is worthy of consideration in view of the fact that in those parts of the Roosevelt elk's range where this territorialism was evident "outrider bulls" and the consequent annoyance and harassment to the harem bull were almost absent in contrast to the Roosevelt elk in the Olympic Mountains and the Rocky Mountain elk, where this territorialism is absent. Here "outrider" bulls, the unattached mature males, are common and the harassment of the harem bulls is often very severe. Here intimidation of these outrider bulls depends entirely upon physical display and direct physical action upon the part of the harem bull.

In addition to this it has been noted, in that part of the Roosevelt elk's range where territorialism occurs, that when two bulls meet on common ground at the beginning of the rut the first activity on the part of the bulls is to indulge in highly vigorous sign post activity even though one of the animals may be in a favorable position to take over the unattended herd, as when one of the bulls arrives well in advance of the other. Sign post activity is highly abbreviated at such a time and consists primarily of "burring" or scraping the "post" with the base of the antlers and bugling a great deal. Such a behavior may serve as a psychological intimidator through establishment of the first or most numerous sign posts and may enable a bull to take over a herd without having to contest physically for it. This behaviorism as well as the more highly ritualized and complete behavior of the bull with the harem has suggested that possibly there is a similarity in the purpose and effect of the use of antlers in the antler rubbing of other deer.

Antler rubbing is generally given one of two interpretations by layman and students alike, namely, that it is for the purpose of removing the velvet or that it is a combat practice intended to intimidate a rival. A close and critical examination of the evidence leads me to conclude that antler rubbing for the sole purpose of removing velvet does not occur, though in some cases there may be a removal of some velvet incidental to rubbing of antlers for other purposes where the rubbing occurs before all the velvet has dropped off the antlers. I have seen bulls and buck deer go about for days and even weeks with bothersome masses of stripped velvet hanging over their eyes without making an attempt to remove the velvet even though it was obvious that it was causing them a great deal of

annoyance. It is my belief that velvet removal occurs only by accident or coincidence when the sign post behaviorism manifests itself early enough to occur before all the velvet has dropped off of its own accord. Such early rubbing is always rather gentle and hesitant as though the antlers are not yet completely hardened and capable of withstanding heavy pressure and rough use.

A second type of antler use, other than for actual combat, is for slashing and whipping shrubs or saplings when "challenging" other bulls. However, even this may be a misinterpretation, for this type of behavior often occurs when no other bulls are present. It may be significant that such behavior is more common to the resident bull than the challenger or unattached bull. Such behavior is also often accompanied by digging in the soil with the antlers, urinating upon such spots and upon himself, much more a sign post behaviorism than a challenge. The effect on an unattached bull either immediately or later is, I believe, primarily through the signs of such activity rather than the activity itself at the time it is performed. Thus such a display even in the presence of an outrider bull may be more in the nature of an indirect rather than a direct intimidation by impressing territorial possession upon the potential rival and thereby creating a feeling of inferiority in such a rival. The effect of such a psychological condition has already been pointed out, in short, it is a form of "cold war."

What has been said of the antler use by the elk here applies also to the members of the black-tailed deer (*Odocoileus hemionus columbianus*), and my own observations over a period of years as well as the close observations of others indicate that antler rubbing in this species has a significance similar to that in the elk. It is, however, not developed as highly nor does it result in such a complex pattern of behavior as in the Roosevelt elk. As stated, bucks have frequently been observed with the bothersome strands of velvet dangling in front of their eyes without any attempt made to remove them. Antler rubbing usually starts well after all velvet is completely gone. Linsdale (1953) states that in these deer the same rubbing posts are often used year after year. He also mentions that "whipping or thrashing" of limbs and shrubs takes place and he interprets this as being combat practice. He specifically mentions that the bur of the antler is most frequently used in the rubbing activity and cites cases where bucks used overhead limbs, a situation that to me seems most unlikely as a position having any value in combat practice. Most interesting and significant is his description and picturing of a shrub that was virtually reduced to a cluster of short stubs by repeated use as a rubbing or whipping post by bucks during one season. Within a few feet of this abused and tattered shrub is shown and described another shrub of the same plant species and of approximately the same size, equally accessible, which was completely ignored by the bucks.

That antler rubbing in black-tailed deer is not confined to the rut alone is indicated by an observation that occurred on January 13, 1955, after over 50 per cent of the bucks in the region had already dropped their antlers. A two-point buck was observed feeding on an open hillside. The buck approached a loosely branched shrub, three to four feet in height, and proceeded to thrash or whip the outer twigs with the ends of his antlers. This was done by whipping his

antlers in a horizontal arc of one to two feet, while inclining his head forward to bring the antler points to a horizontal position. The whipping was vigorous and purposeful but not violent. Most interesting was that after a period of 10 to 20 seconds of this the buck would pause and very carefully and precisely run his nose over the outer twigs that he had whipped with his antlers. This nosing was done without apparently touching the twigs. The action was very careful and precise with a deliberateness and mannerism that was highly reminiscent of the nosing act of the elk sign-post behaviorism. This intermittent whipping and nosing was repeated six or seven times, after which there was a period of feeding for about ten minutes and then the same process of whipping and nosing was repeated a number of times. No other deer were seen nearby at this time.

The method of antler use, the repeated use of the same posts during a season (as well as year after year by individuals or by different bucks) and the behaviorism just described above, certainly indicates that there is more of significance to these acts than the immediate fulfillment of the need for something upon which the buck can vent his surplus energy and spirits.

Black-tailed bucks usually roam about during the rut and breeding is usually promiscuous. However, it is my observation that certain bucks will at times attach themselves to a group of does and stay with them for a considerable period of time, particularly at the beginning of the rut. Such bucks may be seen as constant attendants to a group of does even though lesser bucks may be tolerated in the group. The group sociability of these deer is apparently not very highly developed, and in keeping with this the possessiveness is not as fixed and developed as in the elk. This would then agree with the less well-developed territorialistic behaviorisms, even though the home range is well established in these deer.

The smaller deer of North America have no organized social groups, or at best associate in groups on favorable feeding or resting grounds. Maternal attachment apparently is limited to the mother and the immediate offspring in contrast to the Roosevelt elk where such maternal attachment may be between several generations within a group. The territorial behavior would therefore not be as highly developed in these deer. The elk on the other hand, with its highly knit family groups and very close attachment to a home range that it can occupy during all seasons of the year has the most specialized territorial behaviorism. Murie, in personal correspondence indicates that there is not such behavior in the Rocky Mountain elk. It has not been observed in the Roosevelt elk in the Olympic Mountains. Both of these regions are areas of seasonal migration. It is not surprising that, in regions where the summer territories are temporary and indefinite and where winter populations are crowded on a common range, territorialism and its behavioristic manifestations are not developed. It may also be significant that in these high mountain areas the rut often takes place under conditions where visibility is quite good and that sign posts would not be as effective or as necessary as in heavily forested regions, such as on the year-round range in the dense coastal forests of southern Washington, Oregon and northwestern California. Here conditions are most suitable for the full realization

and application of such a pattern of behavior. On the other hand, A. W. F. Banfield, Chief Mammalogist of the Canadian Wildlife Service, Ottawa, in personal correspondence, tells me that he has observed several instances of behavior on the part of two cow elk and one bull moose in the Canadian Rockies, near Banff, which may have been abbreviated and modified actions related to the behaviorism described. It may be that the full behaviorism has been overlooked up to this time in these regions.

It is hoped that these observations will call attention to a more interesting and significant approach to the study of the behavior of our deer and that students will, in the light of these observations, in the future examine the behavior of other species of deer for evidence of territorial behavior. It is my belief that, once it is looked for, such behavior will become apparent in various degrees in many other deer, not only in North America but elsewhere.

LITERATURE CITED

DARLING, F. F. 1937. A herd of red deer. Oxford Univ. Press, London. 215 p.

FLEROV, K. K. 1952. Fauna CCCR. Kabargi I Oleni. Vol. 1. Zoologicheski Institut Akademi CCCR.

GRAF, W. 1955. The Roosevelt elk. Port Angeles Evening News, Port Angeles, Washington. 105 p.

HECK, L. 1935. Der Deutsche Edelhirsch. Paul Pary Verlag. Berlin.

KAPLANOV, L. G. 1948. Tigr, Isubr, Los. Moscowskoye Obschestvo Ispitateli Prirodi. Moscow. No. 1.

LINDSDALE, J. M. AND P. Q. TOMICH. 1953. Univ. California Press. Berkeley. 567 p.

San Jose State College, San Jose, California. Received August 12, 1955.

NOCTURNAL MOVEMENTS AND BEHAVIOR OF WILD RACCOONS AT A WINTER FEEDING STATION

BY WARD M. SHARP AND LOUISE H. SHARP

The activities of nocturnal mammals are difficult to study under natural conditions due to their wariness and the unfavorable light conditions that limit observations. The success of such studies usually depends importantly upon the type of situations in which animals are observed. The following investigation was initiated when the writers discovered that wild raccoons were utilizing grain at a winter feeding station almost at their doorstep.

This station, located 60 feet south of the refuge headquarters residence at the Valentine National Wildlife Refuge, Cherry County, Nebraska, had been maintained over a period of years for grouse and pheasants. Shelled corn was placed on a site, approximately six feet in diameter, during early November and the supply was replenished as needed until the following March. Raccoons (*Procyon lotor*) were seen feeding in November, 1940. Nightly observations were initiated late in this month and were continued through each succeeding winter until February, 1943.

The objectives of the study were: (1) To determine the hours of greatest

nightly activity, (2) To study gregariousness and pack dominance, (3) To observe the effects of winds and temperature as a limiting factor in winter feeding, and (4) To study periods of inactivity during the winter.

The authors extend especial thanks and acknowledgements to Dr. C. R. Carpenter, Professor of Psychology, for valuable suggestions on behavior terminology, and to Dr. E. B. Hale, Professor of Psychological Research, The Pennsylvania State University; Dr. Daniel L. Leedy, Dr. C. R. Bourn, and L. M. Llewellyn, U. S. Fish and Wildlife Service for constructive reading of the manuscript.

METHODS AND PROCEDURE

The lawn on which the station was located extended from the residence 150 feet south to the edge of Hackberry Lake. The lake was always frozen over from mid-November to early March. The ice-covered surface served as an avenue for raccoons in crossing from the south shore. This route was closed as a travel lane when the ice went out in the spring.

A beam from a three-cell flashlight would effectively cover the entire lawn area to the edge of the lake from any one of three windows on the southeast side of the house. Raccoons and rabbits in the area could be readily observed and counted. Lights burned in the residence during the early part of the night, but the rays that were cast through the windows did not illuminate the feed station. Lights inside the house were generated by a motor located about 150 feet from the station. This motor ran continuously while lights were burning.

Shifts were arranged by the workers when all night observations were conducted. These breaks came at 12:30 AM. Raccoons in view were recorded at half-hour and hourly intervals prior to 12:30 AM. Only the highest count within the hour was used in Figure 1. Hourly checks were made after 1:00 AM since the raccoons arriving after 1:30 AM were very wary

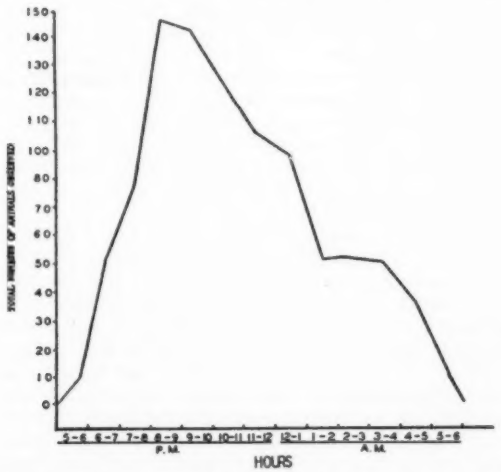


FIG. 1.—Raccoon activity during the hours 5:00 PM to 6:00 AM—based on the total number of animals recorded in 726 observations during the winters of 1940–41, 1941–42, and 1942–43. Counts were made at equal intervals in order to determine preferred periods of nocturnal movement.

and would leave the area when half-hour observations were made. Animals arriving prior to midnight gave little response to the beam of the flashlight. Counts after the latter hour were hurried so that the beam would not disturb the visitors. An individual or group of late night feeders would vanish if spot-lighted too long.

Conditions of weather including wind, temperature, precipitation, and presence of snow on the ground were recorded during all the observation periods. Hourly temperature readings were maintained nightly during the study. The first observation was recorded on the night of November 25, 1940 and the work was terminated on the night of February 13, 1943. The study was initiated in November each year and terminated around the middle of March when raccoons abandoned feeding on shelled corn. During this period 726 observations were recorded. A total of 1095 raccoons, including duplications, was counted and observed. These raccoons were undisturbed in their habitat since trapping or the presence of dogs was not permitted on the refuge. Disturbances by personnel were minimized during the period of the studies.

OBSERVATIONS AND FINDINGS

Wariness.—Raccoons appearing at the station prior to midnight had no observable apprehensions of the vibrations or noise of the motor of the light plant, nor the lights that reflected from the windows. Occasionally, when a neighbor would drive by headquarters over a little-used road, the early feeding raccoons at the station would stop eating, stand tensely, looking towards the approaching noise, then scurry away before the headlights flashed across the lawn to the feed station. Upon returning home by car on an occasional night out, we would carefully survey the lawn for raccoons; only rarely did we see an animal as it went hurrying off into darkness of the lake shore.

The raccoons' senses for detecting humans seemed acute. For example, we were unable to open the door noiselessly on the opposite side of the residence and step silently outside without disturbing them. This was tested by one of us sneaking outside while the other watched the reactions of the raccoons. The animals would immediately raise their heads and sense the person who moved quietly outside the door. If only one animal became apprehensive, it soon imparted it's reactions to the others. The raccoons would leave the area under these conditions of intermittent disturbances, but would tolerate the familiar continuous noise of the light generator.

Raccoons arriving after 1:30 AM were very sensitive and responsive to sounds or lights. This wild behavior, when associated with observed individual markings and other characteristics, enabled us to segregate the after-midnight population from the early-night feeders. The late-night population was alert and apprehensive while those that arrived prior to midnight tolerated the lights and hum of the motor. Apparently the wilder animals, possibly from more remote marsh areas, delayed feeding until the so-called dead hours of the night when the area was in complete silence.

Hourly feeding activities during the night.—Early arrivals following nightfall were mainly yearlings and young of the year, the latter accompanied by their mothers. These large adults with their progeny of one to four cubs would arrive before 10:00 PM. The peak period of feeding activity for the night occurred between 8:30 and 9:00 PM. Approximately 72 per cent of the animals of this group had departed by 12:00 PM. A gradual decline in the numbers occurred during the remainder of the night. Large adult raccoons without young, traveling in pairs or larger groups of three to five in number, began to appear after 10:00 PM. These adults also comprised the late-night feeders. The population when observed over a period was found to be composed of three size or age classes. These were designated as cubs or young of the year, yearlings, and adults (animals classed as 2-years of age or older). The intermediate group, classified as yearlings, was characterized by body outline unlike that of cubs or larger animals. The term "mixed-age groups" when used in this investigation included the three age classes as a population unit.

Observations were recorded from 5:00 PM to 6:00 AM during the period of the study. The total numbers of raccoons recorded hourly during the winters of 1940–41, 1941–42, and

1942–43 are shown in Figure 1. An influx of late-night feeders from 1:30 to 3:30 AM caused the curve to level off. The numbers dropped rapidly after the latter hour and no raccoons were seen after 5:30 AM. The graph represents counts of 1095 raccoons. Counts were made within each hour and represented duplications of the existing population. Frequently one or more raccoons would remain at the station for as long as two hours. Family groups consisting of a female and her cubs rarely arrived after 1:00 AM.

Social status and pack dominance.—Seventy-five to eighty per cent of the raccoon population fed in pairs or packs (two or more) from November to early February. Their approach to the feeder was observed on many occasions. A check of the site would reveal no animals and then, ten minutes later, three or more coons would have arrived simultaneously. Arrivals in packs of three to five were regular, departure was often irregular. Leaving apparently was influenced by the time required for each to reach the point of satiation. The irregular departure suggested that some groups may have disbanded following feeding. Others reassembled near the site before the final exodus. This second-mentioned habit was characteristic of cubs and their mothers.

Groups consisting of an adult female and her young of the year were observed so regularly that identification of family units (female with young) was felt to be reliable. These large females, often three or more, with their cubs, would feed as a group on a circular site about six feet in diameter. This was a tolerant assemblage.

A form of social order or hierarchy was evident within the population. The adult females attended by young of the year displayed a type of dominance over the mixed-age groups of the population. It was concluded that this social status related to her role in rearing the young. Progeny, it was felt, were dominated and led by their parent during their first six months of early life. This persisting response of adult females may have lingered in the adult individual in the form of continued subdomination.

Animals one or more years of age attained their status in social hierarchy partly through pack associations. Two or more adult raccoons arriving at the feeding station as a pack displayed no indications of subdominance when walking into a group already on the feed grounds. Single adult animals upon approaching the station displayed signs of timidity and nervousness and were soon discouraged from feeding with a group. Young raccoons of the year were tolerated by older animals to a much greater extent than were adults. A hurried departure by an individual, when feeding alone, was a clue to the observers that a group was nearing the station. Cubs appearing with their parent were confident within an aggregation of mixed age groups. It was noted that cubs showed security behavior when in a group of ten or more raccoons assembled at the station as long as the parent was present. At times when an adult would leave before her young were satiated, the remaining population would soon drive these cubs to the periphery of the circular feeding site.

A listing of social status within a population of wild raccoons on the feed grounds follows: 1. Females with young; had freedom of movement in feeding area and were not challenged by other adults; tolerated other females with young. 2. Young (cubs); freedom of movement when with mother, otherwise they were driven aside. 3. Individual animals of adult age; would feed when area was not used by *groups* of raccoons; otherwise, compelled to leave until site was again deserted by groups. 4. Groups of adults; two or more would drive away a single individual and would not permit it to return; groups were permitted to mix with other groups following threatening or intimidating gestures.

It was concluded from the behavior patterns that two or more individuals traveling as a pack exerted an intimidating effect on others they chanced to meet. This method of attaining equal social status was valuable when competing for the same source of food. They could hold their ground successfully against a similar group by threatening actions short of fighting. Individuals within packs remained close to the others of the same pack as they walked into a group. Pack cohesion (Pl. 1) upon arrival, and during the period of feeding, appeared to give additional security.

Threatening actions or intimidating gestures were displayed whenever the situation appeared to be competitive. Laying back of the ears, raising of the shoulder hackles and

PLATE 1

A group of three raccoons arriving at the feed station already occupied by several animals not shown in the field. The camera was tripped as the group was being challenged, two posing as silent partners while the third returned the challenge. Baring of the teeth, and laying back of the ears were displayed. The three coons entering as a close compact group were accepted, the challenger withdrawing to its associates.

upon occasion, when these did not produce response, a snarl-like showing of the teeth was observed. These expressions were usually adequate for gaining acceptance into a group. One member of each pack, as a rule, would make the previously mentioned intimidating or threatening gestures with its followers moving in as silent partners (Pl. 1).

In February a change in the temperament of the population was noted. Fighting, resulting in squealing and the characteristic growls were common. The population that had fed peacefully from November through January were seen less often on the feed grounds during February, and by early March animals almost ceased to return at night. Only occasional visits of young coons were recorded during this month. The desertion of the feed station was attributed to two factors, (1) increasing strife with the arrival of the breeding season, and (2) availability of natural foods such as frogs, turtles, and etc., which became available after thawing of the lakes and marshes. Family groups of adult females and cubs had disbanded by the middle of February.

Monthly activities during the winter, and effects of weather.—The population under observation was active throughout the winter months as long as the temperatures were in the 30's following nightfall. Cold waves eliminated feeding activity. Temperatures dropping to 24°F. were the dividing line between activity and semi-hibernation.

Visits to the feed station began to increase in frequency during late November. The peak of greatest use of the feeding station occurred during December. For example, a total of 300 raccoons was observed during December, 1941. Activity during January varied from

year to year depending upon the intensity and duration of the cold periods. Indicating this variation due to the open or prolonged cold weather encountered during this month, 40 raccoon observations were recorded for 1941, 237 for 1942, and 66 for 1943.

Nightly visits to the station in favorable weather during February was usually erratic when compared to the previous months. Increasing competition and a change in temperament of the population contributed to this decrease. On nights when counts of 20-30 were made, fighting outbreaks occurred frequently. These disturbances were followed by relatively few visitors for several subsequent nights when weather conditions were suitable for raccoon activity.

Temperatures.—Low temperatures were considered the controlling factor inducing periods of semi-hibernation in the population. Winter weather in the Great Plains Region included periods of calm or relatively calm weather accompanied by nightly temperatures above 30°F. at nightfall, and cold or cold-windy periods with temperatures below 20°F. for several days duration. Winter activity was stimulated by the warm periods and noticeably retarded by the cold spells.

On calm nights with the temperatures above 30° F. (from 6 PM to 5 AM) raccoons would often feed, but when temperatures were in the upper 30's following nightfall, only to drop rapidly into the lower 20's by midnight, raccoon activity at the station dropped off correspondingly. The latter temperature changes reduced the number of late night visitors after 1:00 AM. Nights preceding cold waves were the exception, and will be discussed under foretelling storms. Experience gained from studies during the first winter enabled us to predict the raccoon population for a given night by noting the temperature and wind velocity at nightfall. Wind velocities were closely integrated with temperatures and were considered the second factor controlling or curtailing activity.

Response by age classes to temperatures.—Tolerance to lowering of temperatures differed somewhat between adults and young of the year. Temperatures around 24° F. discouraged approximately 90 per cent of the total population. Adult raccoons were inclined to "lay up" during periods when temperatures were 24° F. or lower at nightfall, but some of the young animals remained active. The adult population was also erratic and unpredictable on calm nights when temperatures (at 6:00 PM) were hovering somewhere between 30° F. and 24° F.; however, adult females with young would appear. Some animals judged to be 1½-years of age would also arrive.

Our studies show that cub raccoons (young of the year) were inclined to move when the temperature was too cold for adults. Some of these individuals would come to the feed station on nights when the temperatures were between 20° and 12° F. These were small cubs which usually fed alone. Their feeding periods were brief and confined to the early hours of the night prior to 10:00 PM. Only about 10 per cent or less of the total cub population fed on nights when temperatures were below 24° F. Their feeding on cold nights was erratic and very unpredictable. Young animals would feed occasionally during the first night or two following a cold front and then "lay up" until the weather became warmer. These individuals were also the first to appear on the few warm nights following a period of sub-zero weather.

Winds.—Feeding forays of the raccoon population were affected noticeably by winds when accompanied by temperatures around 30° F. or lower. On warm nights (above 32° F.), breezes under 8 m.p.h. had no apparent significance in curtailing activity. Raccoons indicated signs of their numbers becoming variable at the feed station when velocities approached 8 to 10 m.p.h., and at 15 m.p.h. their use of the feed station had noticeably declined.

Late feeders rarely arrived during nights with wind velocities approaching 8 m.p.h. or higher. Some early-night visitors would feed prior to 10:00 PM, but the numbers of these individuals were generally low. The nuisance factor of strong, warm winds no doubt was just as annoying as the physical discomfort inflicted by light, cold winds. Hearing and other means of detecting danger apparently were greatly reduced. The late-night feeders comprised a wary, alert segment of the population. Their apprehension to winds even on warm

nights may have overcome their desire to feed. This phase of animal behavior is worthy of further investigation. Do winds stimulate sleep and sluggishness in mammals that depend upon hearing as one means of survival?

Effect of snowfall on activity.—The population indicated a general intolerance to snowfall. Snow prior to late February was dry and powdery, wet snows were more frequent with the approach of March. It was noted that warm periods preceding and during thaws in December and January were not conducive to raccoon activity.

Their period of semi-hibernation was more prolonged following a cold period accompanied by snowfall than it was following cold waves that produced no precipitation. Groups of raccoons were often feeding when a snowstorm started around midnight. Some would continue feeding on corn until their backs were white with snow. None would arrive when snowfall fell prior to and during nightfall. An occasional animal would move during wet snows in late February, but these individuals represented only a small part of the population. Experience with the habits of the raccoons under study led us to believe that snowfall prior to mid-February produced a discomfort stimulus that induced semi-hibernation of greater intensity than that resulting from snowless periods of sub-zero temperatures. Studies in animal behavior regarding the validity of the above would be of practical value in wildlife management. The low harvest of black bears in Pennsylvania, for example, during 1953 was believed influenced by the heavy snowfall preceding the open season.

Capacity of the population to foretell storms.—The raccoons under study apparently were able to sense approaching storms at least 48 hours in advance of their arrival. We were unable, by observing the behavior of the population, to determine the magnitude of these changes in weather except that temperatures would drop drastically. Strong winds with periods of zero or near zero weather were sensed by the adult population. Animals were more tolerant of lowered temperatures during the first and second nights preceding storms of several days duration than was the case during periods of fair weather. Temperatures during the nights of December 23 and 24, 1941, for example, remained below the usual tolerance range of the population. Twelve raccoons visited the station up to 11:00 PM of December 24. Snow accompanied by a light wind began falling at 10:00 PM. Some individuals remained for an hour after the storm had arrived. Sixteen days of cold, windy weather, with temperatures 10° above to 10° below zero F., ensued.

Raccoons fed prior to storms in an excited and hungry manner, gorging, it would appear, with corn. The following is cited as a typical situation when a cold wave arrived accompanied by high winds and sub-zero temperatures. Thermometer readings on the night of January 5, 1943 were 36° F. at 6:00 PM; 31° F. at 9:00 PM; 15° F. at 12:00 PM; and 9° F. at 4:00 AM. Thirty-one raccoons visited the station, but the population had vanished by midnight. Adult animals arrived when temperatures were in the 30's, but several remained to feed after temperatures had dropped to 20° F., which was below the tolerance range in fair weather. A cold front with high winds roared in at 1:30 AM. The population had departed at least 1½ hours in advance of the onset.

SUMMARY

A study of the nocturnal activities of a wild population of raccoons was conducted during the winter months of 1940–41; 1941–42; and 1942–43. Observations were recorded on the hours of nightly activity, pack dominance and social status, response to temperatures, winds, snowfall and the ability to foretell storms. The work was conducted in north central Nebraska beginning each year in late November and terminating in March.

Raccoons demonstrated acute senses for detecting approaching danger on calm nights. Windy nights appeared to impair this ability.

The majority of the population had fed and departed prior to midnight. A wary segment of the population arrived between 1:30 and 3:30 AM. Data on

observations revealed that 72 per cent of the animals had retired from the area by midnight.

A form of social order existed in the population. This behavior enabled the various segments of the society to share the same source of food. Threatening or intimidating gestures were displayed when necessary to gain acceptance to feed grounds.

The population was active throughout the winter months during mild weather.

Temperatures and winds were controlling factors limiting nocturnal activity. Thermometer readings at 24°F. or below caused the adult population to "lay up" in semi-hibernation. Cub coons were inclined to be abroad on nights when the cold was too great to be tolerated by adults. Winds affected movements noticeably. Warm winds approaching 8 to 10 m.p.h. caused the population to become erratic. Stronger winds curtailed early-night visitors and eliminated the after midnight visitors.

The population possessed an acute ability to foretell storms. Approaching cold fronts were detected by the adults at least 48 hours in advance.

Pennsylvania Cooperative Wildlife Research Unit, The Pennsylvania State University, University Park. Received August 10, 1955.

STUDIES OF MATERNAL RETRIEVING IN RATS
I: RECOGNITION OF YOUNG

By Frank A. Beach and Julian Jaynes

Many naturalistic reports indicate that lactating females of many mammalian species are capable of discriminating between their own offspring and other young of the same age. "Recognition behavior" of this sort has been reported to occur in the Alaskan fur seal (Bonnot, 1929; Preble, 1923), elephant seals (Hamilton, 1934), domestic sheep (Fraser, 1937; Scott, 1945), Dall sheep of Mt. McKinley (Murie, 1944), red deer of Scotland (Darling, 1937), American elk (Altmann, 1926), and mule deer (Linsdale and Tomich, 1953). The most extensive investigation of maternal behavior in the laboratory rat lead Wiesner and Sheard (1933) to conclude that similar discrimination does not occur in this species.

In studies of maternal activity in the rat (*Rattus norvegicus*), the senior author became convinced that some female rats do react selectively to their own young. The present study was conducted to determine whether or not discrimination does occur, and to discover if possible the nature of the cues involved.

This study is part of a larger investigation conducted in the Department of Animal Behavior at the American Museum of Natural History and supported by a grant from the Committee for Research in Problems of Sex, National Research Council.

Subjects and methods.—Ten primiparous and six multiparous female rats of a

strain derived from Wistar stock served as experimental subjects. No differences were found between the maternal reaction of multiparous and primiparous individuals, and the results of their tests have therefore been combined.

Approximately five days prepartum each pregnant female was placed in an observation cage three feet square and one foot deep and supplied with paper strips as nesting material. Cages were divided in half by a partition pierced by a small doorway. All cages were situated in a quiet, dimly-lit room, the temperature of which was held at 80°F ± 5°. Females remained in the observation cages until all testing was concluded.

Retrieving tests were conducted in the following fashion. The female was gently removed from the cage and placed in an adjacent release chamber. Young were removed from the nest by forceps to avoid contamination with human body odor, and placed at predetermined locations on the cage floor. In all tests six pups were used. Sometimes these were young of the mother to be tested. In other instances they were alien young the same age as the subject's litter. In still other tests alien and "own" young were presented.

After the young had been distributed the sliding door to the release chamber was raised and the female was allowed to enter the observation cage. When she did so the door was closed behind her, a timer was started, and a running record of her retrieving behavior was kept until the last pup had been returned to the nest or until one hour had elapsed.

In three of the females the sensory nerves to the snout and lips were sectioned prior to parturition. Three other cases were tested for retrieving for three to five days postpartum and were then rendered anosmic by cauterization of the olfactory bulbs. Following recovery from the operation additional retrieving tests were conducted.

Results.—Three females were tested with six of their own young and, either one day before or one day after this test they were given six alien young to retrieve. The results are illustrated in Figure 1. We have calculated the median number of seconds to retrieve each successive pup, and the figure presents cumulative scores. In both the tests with "own" and with alien young, the median time to retrieve the first pup was six seconds. However, the second pup was retrieved in 12 seconds during the test with "own" young, and not until 51 seconds when alien young were offered. Figure 1 demonstrates that lactating rats will retrieve alien young, but that they do so more slowly than they retrieve their own offspring.

Seven females were given a total of 18 tests in which they were presented with five of their own offspring and one alien young of the same age. One female showed no discriminatory behavior, but the remaining six animals tended to reject the alien pup at first. This occurred one or more times in seven of 17 tests. The intensity of rejection behavior ranged from an initial hesitation and prolonged investigation of the alien pup to as many as five successive rejections before the alien pup was finally seized and transported to the nest.

Preferential retrieving was most clearly shown by one female tested with five alien young and one of her own litter. This animal investigated and rejected

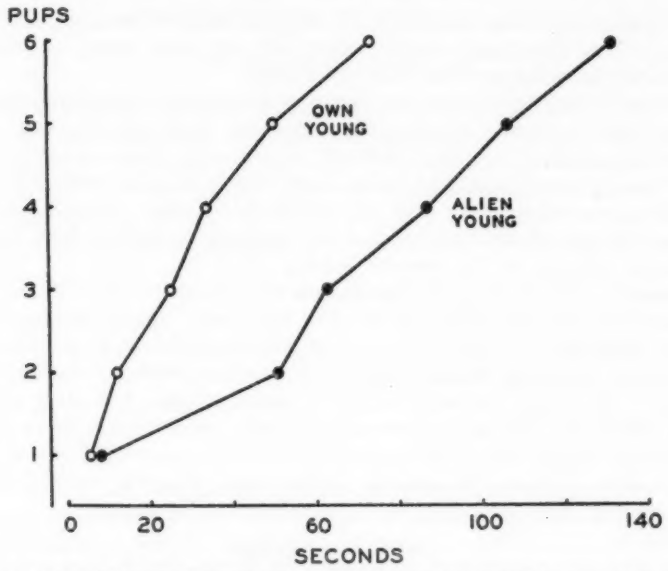


FIG. 1.—Cumulative median number of seconds to retrieve successive pups in tests with six of the mother's own pups and with six alien pups.

each of the alien young, discovered and promptly retrieved her own pup, and only then returned to retrieve the five aliens in quick succession.

Three females deprived of cutaneous sensation in the snout and lips were observed in 11 tests in which they were offered five "own" pups and one alien young. Desensitization did not destroy the ability to discriminate between the female's own offspring and a foster pup. In six of the 11 tests the alien pup was retrieved last. Twice it was the fifth out of six animals to be taken to the nest. In two tests the alien young was the second pup to be retrieved, and in one instance it was retrieved first.

The three animals subjected to destruction of the olfactory bulbs were tested for discriminatory retrieving prior to operation, and all of them showed a tendency to reject alien young. Two females were tested twice and the third animal was tested once. Discriminatory behavior was observed in every test and there were a total of 11 rejections in 5 tests. Following the loss of olfactory sensitivity retrieving ability was unimpaired but "own" and alien young were retrieved indiscriminately. In none of the seven postoperative tests was there a single instance of rejection.

Discussion.—Wiesner and Sheard (1933) found no evidence of discriminatory retrieving when female rats were offered alien young. However, their method of presenting pups to be retrieved was to drop them, one at a time, through a delivery chute. Under these circumstances a female had no opportunity to display preferential tendencies in retrieving. The tests used in the present study

were considerably more sensitive. We feel justified in concluding that some female rats do discriminate between their own and alien young, and that the critical cues involved are of an olfactory nature.

A female might identify her own young on the basis of distinctive odors correlated with genetically determined, biochemical characteristics. Our results do not rule out this possibility. However, we are more inclined to believe that "own" young are distinguished on the basis of nest odors to which the female herself has contributed. An alien pup might be expected to smell "strange" because his own mother and her nest are olfactorially distinct from those of the female whose retrieving behavior is being tested.

Summary.—Sixteen lactating female rats were tested for retrieving reactions to their own and alien young. Both alien and "own" young were eventually carried to the nest, but alien pups were retrieved more slowly. In a choice situation, all but one of the females displayed some discriminatory behavior, rejecting alien young one or more times before retrieving them but never rejecting "own" offspring. Surgical elimination of cutaneous sensitivity in the snout and lips did not destroy the discriminatory behavior, but removal of the olfactory bulbs totally eliminated differential responsiveness with the result that alien young were accepted as readily as the female's own offspring.

LITERATURE CITED

ALTMANN, M. 1926. Social behavior of elk, Cervus canadensis nelsoni, in the Jackson Hole area of Wyoming. Behavior, 4: 116–143.

BONNOT, P. 1929. Report on the seals and the sea lions of California. California Division Fish, Game, Fisheries Bul., 14: 1–62.

DARLING, F. F. 1937. A herd of red deer. Oxford Univ. Press., London.

FRASER, A. 1937. Sheep farming. Crosby Lockwood, London.

HAMILTON, J. E. 1934. The Southern sea lion (Otaria byronia De Blainville). Discovery reports. Cambridge Univ. Press, 8: 268–318.

LINSDALE, J. M. AND P. Q. TOMICH. 1953. A herd of mule deer. Univ. of California Press, Berkeley.

MURIE, A. 1944. The wolves of Mount McKinley. Nat. Park Ser., U. S. Dept. of Int., Fauna Series, No. 5.

PREBLE, E. A. 1923. Mammals of the Pribilof Islands. North Amer. Fauna, 46: 107.

SCOTT, J. P. 1945. Social behavior, organizations, and leadership in a small flock of domestic sheep. Comp. Psychol. Monogr., 18: 1–29.

WIESNER, B. P. AND N. M. SHEARD. 1933. Maternal behavior in the rat. Oliver and Boyd, Edinburgh.

Department of Psychology, Yale University, New Haven, Connecticut. *Received June 23, 1955.*

ECOLOGY AND HEALTH OF *RATTUS* AT NOME, ALASKA

By Everett L. Schiller

Nome is the most northerly coastal locality in Alaska where the brown rat, *Rattus norvegicus* Berkenhout, has become established. In winter the physical environment of rats living under marginal and submarginal conditions at this latitude (64°30′) is quite extreme. A parasitological study of these rats was begun in December, 1952, during which some notes were also made on the effect of winter conditions on this population. These observations are reported herein.

MATERIALS AND METHODS

The field work was conducted at Nome during the months of December (1952), April (1953), September (1953), January (1954), and January (1955). Rats were collected from various habitats, either by trapping or poisoning. Specimens were autopsied and examined as they were obtained during the field work, and appropriate tissue specimens were collected for later histopathological study. Additional carcasses of rats were preserved by freezing and examined upon return to the laboratory at Anchorage. Inoculations of laboratory animals and of bacteriological media were made at the time of autopsy in the field from various organs of recently killed rats. After the desired interval of time, the laboratory animals were killed and examined. Preliminary incubation of the bacteriological media was carried out at Nome. Where growth was evident in vials or on plates upon return to the laboratory, smears were made before subculturing. Smears were stained with acid-fast and Gram stains. Heart and kidney impression smears were stained with Giemsa's stain and examined for *Spirillum minus* Carter, and for the presence of trypansomes. A series of serum specimens was collected from both rats and dogs in Nome, and agglutination tests for *Leptospira* were made at the Communicable Disease Center, Public Health Service, Chamblee, Georgia.

Tissues for histopathological study were fixed in either formalin-acetic acid-alcohol (AFA) or 10 per cent formalin. Histopathological examinations of lung and kidney tissues of the Nome rats were made at the Rocky Mountain Laboratory, Public Health Service, Hamilton, Montana. Testicular tissues, for the determination of spermatogenesis, were fixed in 10 per cent formalin and embedded by the paraffin method. Sections were stained routinely with hematoxylin-eosin.

Cestodes were fixed in AFA and stained in Semichon's acetic carmine stain. Nematodes were cleared for study in liquefied phenol. Diagnosis of trichinosis was made by demonstrating the presence of larvae in diaphragm muscle by the compression method. Ectoparasites were preserved in 70 per cent alcohol.

OBSERVATIONS AND DISCUSSION

The writer has been unable to find any recorded information on the origin of the rat population of Nome. However, according to a number of the oldest residents, rats were first introduced when the great barge *Skookum*, one of the largest on the Pacific Coast at

that time, was wrecked at Nome during a storm beginning September 11, 1900. The newspaper files of the Alaska Historical Library and Museum (*Nome Nugget* and *Gold Digger*) disclosed that the *Skookum* drifted ashore on September 12, 1900. One end was intact, and much of the cargo was salvaged by driving a scow between the grounded barge and the beach. Any rats aboard could easily have come ashore.

The results of the present study indicate that a high rate of reproduction occurs in rats at Nome during the summer, resulting in a very dense population by fall or early winter. Seasonal movements are very pronounced. Rats that obtain harborage in heated buildings with an available food supply have little difficulty in surviving the winter; however, winter has a rather drastic effect on rats living under less favorable conditions. The absolute minimum January temperature in Nome is −47°C. and days colder than −40°C. are frequent (U.S.D.C. Weather Bureau Climatological Data, Alaska, 1954). Mortality seems to be especially high during this season, and the effect of low temperatures on the surviving population is manifested in a number of ways.

Ecology.—Rats at Nome are restricted to the modified environment of man. During this investigation the rat population was continuous along the waterfront from the military reservation dump northwest of the city to the city dump southeast of the city, a distance of about three miles. These dumps constituted centers of high rat population density. Another such "center" was located within the business district of the city itself. The remains of a burned-out bakery, which had also housed frozen-meat storage in the basement, provided both harborage and an abundance of food for a great many rats. Although, at the beginning of winter, many of these rats sought the protection of adjacent buildings, most of them were compelled to obtain their food from sources outside.

The two dumps were similar in size and composition except that the military dump contained a greater quantity of food in the form of "wet" garbage from messing facilities on the installation. Many of the rats remained in these dumps despite the onset of cold weather. On very cold, clear days and nights in mid-winter, small clouds of vapor could be seen rising from the innumerable openings of rat burrows all over the dumping grounds. Although little food was available, the refuse-strewn beach provided ample cover for rats to move between these population centers. Comparisons of the prevalence of parasitism and disease among groups of rats obtained from each of these main localities suggested that some contact existed between them, although it was doubtful that movements from one center to another were very frequent. Of 60 rats taken from each of these three localities in December, 1952, 20 per cent (12) from the site of the burned-out bakery had severely infected lungs (causative organisms undetermined), while only 5 per cent (3) of each group

TABLE 1.—*Summary of data on rats collected at Nome, Alaska*

Date collected	December 1952	January 1954	January 1955	April 1953
Total number	188	94	25	86
Number males	96	31	12	34
Number females	92	63	13	52
Number pregnant	4 (6.4%)* (62 ♀♀ over 150 grams)	0	0	4 (15%)* (27 ♀♀ over 150 grams)
Number infected with *Hymenolepis nana*	30 (16%)	9 (9%)	0	12 (13.5%)
Number with lung infections	13 (7%)	2 (2%)	0	0
Number with frozen feet	72 (38%)	62 (67%)	17 (70%)	11 (12.5%)

* Percentage of rats pregnant based on visible pregnancies.

PLATE I

Male brown rat, captured alive at Nome in January, showing damage resulting from frost-bite.

taken from the dumps had similar infections. In this same connection, all of the rats from the site of the burned-out bakery were parasitized by fleas, but only 10 per cent (6) of each group collected by the same method in the other areas harbored these parasites.

The most apparent effect of low temperature on rats living outside in winter was that resulting from frost-bite. The first rats obtained that showed evidence of this condition were collected in late December. The percentage of affected animals had almost doubled in the collections made in late January (Table 1). In order to eliminate the possibility that such freezing had occurred during exposure while restricted in the traps after capture, more that 30 were live-trapped during January and removed from the traps as soon as they were caught. The frost-bite conditions among these rats ranged from slightly injured ears and tails to severely damaged extremities (Pl. I). In some cases only one or both of the front feet were involved, but usually all four feet were damaged. Several rats were obtained whose phalanges, metatarsi, and tarsi were completely missing. The captive rats were maintained for several days at room temperature. Swelling, blistering and inflammation followed thawing of the affected extremities and a number developed large suppurative lesions on the soles of their feet. Four of the animals died during the first week of captivity. Practically all of the others whose feet had been frozen appeared to be seriously handicapped and it seemed improbable that any of these would have survived under natural conditions. On the basis of poisoning and trapping results in April, 1953, a drastic reduction in the population had occurred. Of the animals collected at this time, none had lung infections and the percentage of animals with evidence of frost-bite was relatively low (Table 1).

Krog, Monson, and Irving (1955) measured the metabolic rate of wild rats (*R. norvegicus* captured in winter at Fairbanks, Alaska) during exposure to cold. They found that some animals raised their metabolism more than 6 times their basal rate during exposure to −40°C. These authors suggested that this ability of wild rats to suppy a greater metabolic output in cold may be associated with their intensely active and energetic behavior. Al-

TABLE 2.—*Relation between weight and presence of placental scars in Nome rats*

Weight group	Perforate ♀♀ examined	Placental scars		
		Number	Range	Average
grams				
70–89	0	0	—	—
90–109	0	0	—	—
110–129	8	0	—	—
130–149	8	0	—	—
150–169	3	0	—	—
170–189	7	4	(12–14)	13
190–209	7	3	(11–20)	17
210–229	11	8	(4–26)	19
230–249	8	8	(9–40)	27
250–269	8	8	(10–30)	23
270–289	4	3	(12–30)	21
290–309	3	2	(22–29)	25
310–329	6	6	(30–40)	34
330–349	4	4	(39–55)	44
350–369	2	2	(27–34)	30
370–389	2	2	(30–39)	34
390–409	1	1	(71)	—
410–429	2	2	(41–47)	44
430–449	0	0	—	—

though some of their animals were exposed to −40°C. for as long as one hour and 48 minutes, none suffered frost-bite (personal communication). In view of the damage resulting from frost-bite in the Nome rats, it is probable that these animals, in nature, expose themselves to cold frequently and for prolonged periods of time. Such exposure may be associated with the necessity of obtaining food, especially if the competition is particularly keen.

Reproductive activity in the Nome rat population appears to be appreciably restricted during the winter season. Relatively few pregnant or lactating females were obtained during the months of December and January (Table 1). According to Davis and Emlen (1948), it is possible to determine the size at which rats attain sexual maturity by the presence of placental scars. Since this might also reflect indirectly any effect low temperatures and other unfavorable environmental conditions may have on reproductivity, the relation between weight and the presence of placental scars in the Nome rats was tabulated (Table 2). The body weight at which 50 per cent of the rats had placental scars was determined according to the method of Davis and Emlen (*loc. cit.*) by plotting the percentages on arithmetic probability paper and drawing a line by inspection. The body weight was read at the junction of this line and the 50 per cent line. The weight at which 50 per cent of the Nome rats had placental scars was 244 grams. Presumably by the same method, Davis (1949) calculated this weight for the Baltimore rats and reported it to be 242 grams. On the basis of these weights the Nome rats do not differ significantly from the Baltimore rats in the size at which they reach sexual maturity.

Spermatogenesis also seems to be arrested during this season since no spermatozoa were seen in the microscopic examination of histological sections of testes from 25 adult animals collected late in January, 1955. Relatively few of the male rats collected at Nome during the winter had scrotal testes.

According to the weight-records obtained, the rats at Nome apparently do not attain the size that is usually found in similar population samples. The weights of 172 males in this series ranged from 30 to 485 grams. The weight-range of 221 females was from 28 to 426 grams. In comparison, rats weighing more than 500 grams were commonly collected by

the writer in Wisconsin as well as on Adak Island, Aleutian Islands, Alaska, and animals weighing over 600 grams were not unusual in these collections (Schiller, 1949; 1952). Nearly eight per cent of 1432 rats collected in Baltimore (Davis, 1949) weighed more than 500 grams. In view of the marked difference in maximum weights, it appears that existence under marginal conditions at low temperatures either has an adverse effect on growth of these animals or selectively eliminates rats as they become old, resulting in a population of young animals. Since it was calculated that the Nome rats attain sexual maturity at about the same size as the Baltimore rats, the latter proposition seems to be more tenable.

Other observations on the Nome rats gave the impression that some were actually impeded in their movements because of a stiffness or numbness resulting from prolonged exposure to cold. One such animal was observed in a nearly empty, unheated warehouse. This rat was frightened from behind some packing cases. It ran stiffly across the concrete floor and headlong into a solid object in its path. The impact was of sufficient force to stun the animal momentarily. Two animals were found frozen in this building, and it was believed that freezing had been the cause of death.

Compared with those from more temperate localities, no significant difference was noted in the length or thickness of the fur of the rats collected at Nome.

Parasites.—As compared with rats (*R. norvegicus*) from other parts of North America, those at Nome are parasitized by relatively few species. Of 393 rats examined for helminths, 51 (13 per cent) harbored the dwarf tapeworm, *Hymenolepis nana* (v. Siebold, 1852). The relation between host-weight and the presence of *H. nana*, according to the time of the year collected, is shown in Table 3. The only other helminths found in these rats were the nematodes *Trichosomoides crassicauda* (Bellingham, 1840) and *Trichinella spiralis* (Owen, 1835). *T. crassicauda* was found frequently in the urinary bladder at the autopsy of fresh carcasses but was seldom seen in animals that had been kept for several months in frozen storage.

TABLE 3.—*Relation between weight and presence of Hymenolepis nana according to time of year collected*

Weight group	December 1952		January 1954		January 1955		April 1953	
	Number examined	Number parasitized	Number examined	Number parasitized	Number examined	Number parasitized	Number examined	Number parasitized
grams								
25–49	10	0	0	0	0	0	0	0
50–74	7	0	1	0	0	0	13	0
75–99	8	1	0	0	0	0	10	1
100–124	9	0	0	0	0	0	11	0
125–149	10	3	0	0	4	0	9	2
150–174	18	5	2	0	3	0	6	0
175–199	11	0	2	0	2	0	2	0
200–224	17	1	9	0	2	0	7	2
225–249	25	5	11	1	4	0	4	2
250–274	15	4	5	1	3	0	7	5
275–299	12	2	12	1	6	0	8	0
300–324	14	3	19	1	0	0	3	0
325–349	10	1	12	1	1	0	4	0
350–374	9	2	6	2	0	0	0	0
375–399	4	1	9	0	0	0	0	0
400–424	1	0	3	0	0	0	2	0
425–449	2	0	2	2	0	0	0	0
450–474	1	1	0	0	0	0	0	0
475–499	5	1	1	0	0	0	0	0
Totals	188	30	94	9	25	0	86	12

Disintegration of these fragile worms probably takes place under such conditions. Cross-sections of this nematode were also noted in portions of ureter on slides containing histological sections of rat kidney.

The fleas were identified as *Nosopsylla fasciatus* (Bosc d'Antic) by Dr. George P. Holland, Division of Entomology, Department of Agriculture, Ottawa, Ontario, Canada. Dr. Holland (personal communication) noted that these specimens constituted the most northerly record of this species from the New World. No other ectoparasites were observed.

A hemoflagellate of the genus *Trypanosoma*, probably *T. lewisi* Kent, was found upon microscopic examination of the heart and kidney impression smears.

Bacteria.—As mentioned earlier, several of the rats collected in December, 1952, and a few of those taken in January, 1954, had severe pulmonary infections. Macroscopically, the lungs showed multiple abscesses distributed throughout one or several lobes. When the disease was confined to one lobe, usually the lower one was involved. In the early stage of the infection, the abscesses were filled with a clear fluid. In later stages the abscesses apparently coalesced with attendant destruction of lung tissue. The lobes then contained soft, thick, greenish-gray pus. In the most advanced cases these had become caseous. In some instances pleural fibrous adhesions were observed. Dr. W. J. Hadlow, who studied the histological sections of infected lungs, reported that microscopic examination revealed hyperplasia of the alveolar septa with obliteration of some alveoli, and variable lymphocytic perivascular infiltration. Thickening of the bronchial wall by lymphocytes was also noted. A section of a nodular mass containing white foci scattered throughout, showed bronchitis with peribronchial fibrosis. The bronchial lumina contained neutrophils and macrophages, along with mucus. The epithelial lining showed considerable hypertrophy in some areas and partial desquamation in others. No microorganisms were demonstrated in sections prepared with Gram stain, periodic acid-Schiff, and silver impregnation.

The following media were inoculated, in the field, with purulent material direct from the lesions in recently killed rats: liver infusion agar; brain liver heart (semisolid medium); tryptose phosphate broth; brain heart infusion broth; and MacConkey agar. The subsequent bacteriological work on the inoculated media was done at the laboratory at Anchorage by Dr. Harold Fournelle. Subcultures were undertaken and out of 44 isolated cultures, 30 representatives were selected for identification. The following organisms were identified: *Micrococcus flavus* Trevisan; *Micrococcus aurantiacus* Cohn; *Micrococcus candidus* Cohn; *Micrococcus* sp.; *Escherichia coli* Castellani and Chalmers; *Escherichia intermedium* Vaughn and Levine; *Alcaligenes faecalis* Castellani and Chalmers; *Aerobacter aerogenes* Beijerinck; and a sporeforming *Bacillus* sp. All smears were negative for acid-fast organisms. In commenting on these findings, Dr. Fournelle stated, "the identity of the cultures does not fit very well with the pathology in question. It is my belief that the above listed organisms can be considered as either parasites or saprophytes and do not have a direct bearing on the disease."

While in the field the writer attempted to reproduce the disease in hamsters and guinea pigs by the intraperitoneal injection of either an emulsion in saline of pus taken directly from a rat lung abscess, or with emulsified infected lung tissues. None of the recipient animals showed evidence of any disease at autopsy.

Smith, Bethune, and Wilson (1930) reported on their study of the etiology of a fatal pulmonary disease in the albino rat, the pathology of which closely resembles that seen in the Nome rats. From a review of the literature and from the results of their own work, they concluded that there is no one common etiological agent in the lung disease of the albino rat. Among the different types of organisms considered capable of producing pulmonary infections in the albino rat, they listed *Bacillus actinoides*, *Bacillus bronchisepticus*, *Bacillus muris*, and a species of *Streptothrix*.

An attempt was made during this investigation to determine whether the Nome rats carried the etiological agents of rat-bite fever (Sodoku, caused by *Spirillum minus*, and Haverhill fever, due to *Streptobacillus moniliformis* Levaditi, Nicolau and Poincloux, according to Jellison, 1955). Two hamsters and three guinea pigs were given intraperitoneal

injections of pooled rat kidney-heart emulsion. Heart impression smears and heart and kidney tissues were also prepared and examined. No evidence of *Spirillum minus* infection was found. Jellison (1955) noted that the middle ear and lungs of wild rats are consistent sources of infection with *Streptobacillus moniliformis* and that some strains of this organism produce infections in mice, with arthritis the chief manifestation. In this study seven albino rats were given foot inoculations with saline-washings from the middle ears of an equal number of wild rats. Thirteen days later four of the inoculated animals had swollen and inflamed feet. These rats were sent to Dr. W. Jellison at the Rocky Mountain Laboratory where transfers were made to albino rats and mice and to appropriate bacteriological media. None of the cultures proved to be positive for *S. moniliformis*.

Sera from 12 old rats captured at Nome in December, 1952, were sent to the Communicable Disease Center Laboratories where agglutination tests for the diagnosis of leptospirosis were undertaken by Dr. M. K. Ward. All specimens were negative. However, sera from three of four Nome dogs, obtained at the same time, were positive for *Leptospira canicoli* and *Leptospira pomona*. According to Jellison and Reinhard (1955), *L. canicola* readily infects man.

Control.—Inasmuch as the rats at Nome occur only in the modified environment of man, the problem of controlling them is not especially difficult. The combined effects of severe frost-bite, the presence of a chronic and frequently fatal pulmonary disease in this population, and other conditions discussed herein probably account for the marked reduction in numbers of rats that occurs by the end of winter. Rats that have passed the winter within heated buildings, move outside after spring "break-up" and the coming of warm weather. These animals constitute the main breeding nucleus for the new population. A high rate of reproduction soon results in a dense population. These observations suggest that the most effective and economical eradication could be achieved by undertaking rodent-control measures in the spring when the population is already at a low level of density, and before this increase begins.

SUMMARY

A parasitological study of rats (*Rattus norvegicus* Berkenhout) was undertaken at Nome, Alaska, and some notes were made on the effect of winter conditions on this population. A high rate of reproduction during the summer results in a dense population by fall. Mortality among rats living under marginal conditions during the winter is especially high. Some principal manifestations of the adverse effect of low temperature on the surviving animals are: damage resulting from severe frost-bite ranging from slightly injured ears and tails to the loss of limbs; arrested reproductive activity during the winter; and a smaller maximum size than is usually found in similar population samples.

Nome rats are parasitized by relatively few species. Of 393 rats examined for helminths, 51 (13 per cent) harbored the dwarf tapeworm, *Hymenolepis nana* (v. Siebold, 1852). The only other helminths found were the nematodes *Trichosomoides crassicauda* (Bellingham, 1840) and *Trichinella spiralis* (Owen, 1835). Fleas, *Nosopsylla fasciatus* (Bosc d'Antic), were highly prevalent on rats from one of the population centers located within the business district. These specimens constitute the most northerly record of this species from the New World. A hemoflagellate of the genus *Trypanosoma*, probably *T. lewisi* Kent, was also recorded.

Several of the rats had severe pulmonary infections. This disease probably contributed significantly to the winter mortality. The following species of bac-

teria were identified from cultures inoculated with purulent material direct from the lesions: *Micrococcus flavus* Trevisan; *Micrococcus aurantiacus* Cohn; *Micrococcus candidus* Cohn; *Micrococcus* sp; *Escherichia coli* Castellani and Chalmers; *Escherichia intermedium* Vaughn and Levine; *Alcaligenes faecalis* Castellani and Chalmers; *Aerobacter aerogenes* Beijerinck; and a sporeforming *Bacillus sp.* None of these is believed to be the primary cause of the disease. Attempts to reproduce the disease in laboratory animals by intraperitoneal injection of material from infected lung tissues were unsuccessful.

No evidence of *Spirillum minus* Carter, nor *Streptobacillus moniliformis* Levaditi, Nicolau and Poincloux, was found in tests to determine whether the Nome rats carried the etiological agents of rat-bite fever.

Agglutination tests on sera from these rats for the diagnosis of leptospirosis were negative. However, sera from three of four Nome dogs, obtained at the same time, were positive for *Leptospira canicola* and *Leptospira pomona.*

It is suggested that the most effective and economical eradication of rats at Nome could be achieved by undertaking rodent-control measures in the spring when the population is at a low level of density, and before reproduction begins.

LITERATURE CITED

DAVIS, D. E. 1949. The weight of wild brown rats at sexual maturity. Jour. Mamm., 30: 125–130.

DAVIS, D. E. AND J. T. EMLEN, JR. 1948. The placental scar as a measure of fertility in rats. Jour. Wildlife Mgt., 12: 162–167.

JELLISON, W. L. 1955. Rat-bite fever. *in* Hull. Diseases transmitted from animals to man. Ed. 4, Springfield. 717 p.

JELLISON, W. L. AND K. REINHARD. 1955. Leptospirosis. *in* Hull. Diseases transmitted from animals to man. Ed. 4, Springfield. 717 p.

KROG, HILDUR, MILDRED MONSON, AND L. IRVING. 1955. Influence of cold upon the metabolism and body temperature of wild rats, albino rats and albino rats conditioned to cold. Jour. Appl. Phys., 7: 349–354.

SCHILLER, E. L. 1952. Studies on the helminth fauna of Alaska. V. Notes on Adak rats (*Rattus norvegicus* Berkenhout) with special reference to helminth parasites. Jour. Mamm., 33: 38–49.

SCHILLER, E. L. AND B. B. MORGAN. 1949. The incidence of parasites of *Rattus norvegicus* in Wisconsin. Jour. Parasit., (Suppl.), 35: 40.

SMITH, D. T., N. BETHUNE, AND J. L. WILSON. 1930. Etiology of spontaneous pulmonary disease in the albino rat. Jour. Bact., 20: 361–370.

Zoonotic Disease Section, Arctic Health Research Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Anchorage, Alaska. (Current address: Department of Parasitology, The Johns Hopkins University, Baltimore 5, Maryland) *Received July 20, 1955.*

RESPONSES OF SMALL MAMMAL POPULATIONS TO LOGGING OF DOUGLAS-FIR

By Lloyd Tevis, Jr.

Virgin forest in the Douglas-fir (*Pseudotsuga taxifolia*) region of northwestern California is a sterile habitat for wildlife. Dense shade and competition from large old trees prevent the growth of nearly all bushy and herbaceous vegetation except a weak understory of tan oak (*Lithocarpus densiflora*). Food for animals is scarce.

The immediate effect of logging is to flood the ground with light. Then tan oak begins a rapid, aggressive growth, and many kinds of herbs, of which fireweed (*Erechtites*) is one of the most abundant, become established. In terms of plant succession, the cutover changes from bare ground to weeds to brush and finally to a climax of Douglas-fir or more often, tan oak. During the middle stages, food for animals is plentiful.

Small seed-eating mammals are one of the factors that result in the economically undesirable climax of oaks instead of conifers. Mice in particular, because of their fondness for coniferous seeds, are responsible in part at least for the failure of natural seeding to restock many cutovers with firs; and they make artificial seeding difficult and often impossible.

In the Douglas-fir region of California, large tracts of old timber are slated to be logged within the next few years. The usual method is to clear-cut blocks that are fifteen to twenty acres in size and burn the resulting slash. Before silviculturists can prepare a successful plan for reforesting these cutovers, information is needed about the various factors that hinder coniferous reproduction. As a contribution toward that end, this paper gives the results of a trapping survey of small mammals at elevations between 2,000 and 4,000 feet in Humboldt and Trinity counties near Salyer. The purpose of the survey, which was undertaken in cooperation with the California Forest and Range Experiment Station of the United States Forest Service, was to determine the kinds and relative numbers of small mammals, particularly mice, that occurred on cutovers of various ages. In the southeastern United States, small mammal populations are low in old stands of loblolly pine, erupt during the first year after logging, and then gradually diminish in numbers (Trousdell, 1954).

The procedure adopted for obtaining comparative counts of animals of different cutovers near Salyer was to set 100 snap-traps for three days and nights on logged land and an equal number in the adjacent virgin forest. Each setting consisted of 67 mouse traps and 33 rat traps at 34 sites. In this way, eleven cutovers ranging in age from three months to twenty years and their adjoining forests were investigated. No attempt was made to determine actual numbers of animals per acre—an objective that often results in unreliable figures (Stickel, 1946).

In the discussion that follows, the numbers of animals captured are not given on the basis of "trap-nights", because when comparative results are desired that term is misleading. For example, a placement of 300 traps for one night and

another of 100 for three nights are both equal to 300 trap-nights. Yet the first placement, which covers three times as much ground, will catch more animals than the second. The reason is that when traps are set at the same sites for more than one day, the largest catch may be made during the first twenty-four hour period. In this study, 60 per cent of all white-footed mice (*Peromyscus maniculatus*) were taken during the first night, 23 per cent during the second, and 17 per cent during the third. (When a species is scarce, more individuals may be caught during the second or third nights.) Therefore, a statement about the number of traps and length of time they are set is more informative for comparative purposes than is use of the term "trap-night".

Most of the trapping was done between May and November 1952, which was a period when the population of mice was relatively stable. (Some data are included also from trapping in 1953 and 1954.) During that time there was no detectable change in acceptability of walnut meat bait, for the numbers of white-footed mice that were caught in the virgin forest at different trapping periods were remarkably uniform. The average per one hundred traps was 22; the maximum, 24; and the minimum, 15. There was no indication either that these animals avoided the traps, as described by Fowle and Edwards (1954). Usually there was a direct correlation between rate of rodent-robbery of planted coniferous seed and trapping results.

The total kinds and numbers of small mammals trapped were: white-footed mouse (*Peromyscus maniculatus*), 673; Townsend chipmunk (*Eutamias townsendii*), 107; Trowbridge shrew (*Sorex trowbridgii*), 89; big-eared mouse (*Peromyscus truei*), 73; dusky-footed wood rat (*Neotoma fuscipes*), 33; Sonoma chipmunk (*Eutamias sonomae*), 22; red-backed mouse (*Clethrionomys occidentalis*), 15; digger squirrel (*Citellus beecheyi*), 10; flying squirrel (*Glaucomys sabrinus*), 6; shrew-mole (*Neürotrichus gibbsii*), 3; bushy-tailed wood rat (*Neotoma cinerea*), 1; and chickaree (*Tamiasciurus douglasii*), 1. With the exception of the gray squirrel (*Sciurus griseus*), brush rabbit (*Sylvilagus bachmani*), tree mouse (*Phenacomys longicaudus*), and mole (*Scapanus*), the list of 1,033 specimens includes all species of small mammals that occur on cutovers or in virgin coniferous forest of the Douglas-fir belt in the vicinity of Salyer, but comparative figures were obtained only for *Peromyscus*, *Eutamias*, and *Sorex*. So far as foresters are concerned, the white-footed mouse is the most important species. If it were not for this abundant and ubiquitous animal with its enormous appetite for coniferous seed, artificial and natural seeding probably would be successful in the Douglas-fir region. Accordingly, the emphasis in this study was directed towards gaining information about *Peromyscus*, which comprised 72 per cent of the total catch. Other species were investigated incidentally.

White-footed mouse.—In every one of the areas studied, a greater number of mice was trapped on logged land than in the adjacent virgin forest. The difference was least marked on a cutover that was twenty years old, which yielded 28 mice as compared with 24 from the forest; and most pronounced on a six-year old cutover, where 61 were trapped as compared with 15 in the forest.

Trapping results from eleven cutovers of different ages warrant the following

generalization. Within three months after timber has been felled and slash burned, the number of mice is approximately equal to that in uncut forest. Then during the first summer, when weedy vegetation covers much of the heretofore bare ground, the population begins to grow; and within two or three years, as the cutover passes into the weed-brush stage, there is an eruption of mice. From the fourth to tenth years, the animals are three to four times more numerous than in the forest. Afterwards, along with decrease in variety of vegetation, they become less abundant. By the twentieth year, when a solid stand of tan oak has suppressed nearly all other vegetation, the population is scarcely larger than in the original forest of Douglas-fir.

The foregoing summary suggests that the most favorable time for planting coniferous seed on a cutover is in the first fall after logging. Then numbers of mice should be at a minimum. But unfortunately, a small population occupying relatively bare ground often destroys planted seed with greater avidity than does a much larger population inhabiting mixed vegetation. The explanation may lie in the difference between scarcity and abundance of natural food.

As an example, in one area where an intense wild-fire had killed the timber a year previously, the ground was barren of vegetation except for vigorous crown-sprouts of tan oak, madrone, and maple. The mouse population was low. Yet when six hundred seeds of Douglas-fir were planted in one hundred spots at intervals of six feet, the animals dug up and ate or removed all seeds within two nights. The rate of seed spot robbery—100 per cent in two nights—was greater than is normal even where rodents abound.

In this burned area, the natural food of mice, as revealed by stomach analyses, consisted almost entirely of caterpillars, which lived in the clumps of sprouting vegetation. Since the mice appeared to depend on the caterpillars for food, probably the most efficacious form of rodent control would have been elimination of the foliage of tan oak, madrone, and maple with a toxic spray.

Frequent trapping does not protect planted seed from mice because invaders are quick to move into depopulated areas. In one cutover of middle age where fifty traps were set at seed spots for a night each month, there was no appreciable reduction in numbers of captures. In May, 9 mice were trapped; in June, 12; in July, 23; in August, 17; in September, 19; and in October, 14. The slight rise and fall mainly reflected the reproductive cycle of the species in that area.

The advantage to mice of cutovers of middle age is apparent in the density of cover and quantity and variety of food. In such areas, seeds of different kinds might be expected to be the main items in the diet of the animals. Actually, insects are important, as shown by analysis of the contents of 208 stomachs. Insects occurred in approximately 90 per cent of stomachs from both logged and forested land, but they constituted 60 per cent of the volume of the contents of stomachs from cutovers and only 44 per cent from the forest. Therefore, the many kinds of insects that thrive in association with the vegetation of cutovers may be responsible, in part at least, for increased numbers of mice. In the virgin forest, where insects are relatively scarce, mice depend in large measure upon the few kinds of seeds available. Douglas-fir probably is especially important.

TABLE 1.—*Reproductive status of Peromyscus maniculatus adults, given in percentages for each two-month period*

	May-June	July-Aug.	Sept.-Oct.	Nov.-Dec.
Males				
Fertile	100	87	43	100
Not fertile	0	13	57	0
Females				
Estrous cycles	26	9	5	33
Pregnancy	25	16	7	67
Lactation	43	9	12	0
Anestrus	6	66	76	0

Practically no Douglas-fir seed was available during the fall and winter of 1952 because of failure of the cone crop, but the next year there was a heavy production of cones at some places. In October an attempt was made to determine the extent to which mice of one of these areas fed on fir seed. Fifty-two stomachs were examined. Fifty-one per cent contained inner seed coats of Douglas-fir. (A total of one hundred and eleven coats was recovered.) By volume, endosperm of the seed comprised 61 per cent of the contents of stomachs in which it was found and 35 per cent of all stomachs. At that time and place, then, Douglas-fir seed was a principal food of mice.

Data on reproduction were obtained from biopsy of 625 specimens and analyzed by two-month periods. The results, which are given in Table 1, indicate that a period of breeding during the late spring was followed by a summer lull. Then in the fall there was a sudden resurgence of reproductive activity—at about the time when rains usually end the dry season. The cycle was reflected also in the ratio of adult animals to immature individuals in gray pelage. From May through August, the immatures comprised approximately 20 per cent of the population; but from September through November, as a result of the lull in breeding, they comprised only 6 per cent. Sixty-five gravid females were collected. Of these, 1 (2%) had 1 embryo; 6 (9%) had 2; 30 (46%) had 3; 21 (32%) had 4; and 7 (11%) had 5; average 3.4. Embryo count and reproductive status of specimens from cutovers and virgin forest did not differ significantly. Apparently, then, the rapid build-up in cutovers is due to invasion from the outside rather than to increased breeding rate.

Comparisons were made with breeding rates in two other geographical areas. In mid-September, twelve adult males and five adult females were trapped at 6,000 feet altitude on the Modoc Plateau of northeastern California. In contrast to the Douglas-fir region, where breeding did not cease entirely during the summer, all from this relatively arid area were sexually quiescent (anestrus in females).

In the last week of August, 1954, six gravid females were collected from a cutover in the redwoods of the fog belt of coastal Humboldt County immediately west of the Douglas-fir region. Of these, 3 had 4 embryos; 2 had 5; and 1 had 6.

The average of 4.7, compared with 3.4 at Salyer, may reflect an actual difference in reproductive rate between mice of the moist redwood belt and those from the drier Douglas-fir region.

Big-eared mouse.—The white-footed mouse was ubiquitous, living in deeply-wooded as well as brushy areas, but the big-eared mouse did not inhabit the virgin coniferous forest. It required a warmer and more open and varied habitat, such as the oak country along the bottom of the river canyons; the outcroppings of serpentine that support Digger pine (*Pinus sabiniana*) and buck brush (*Ceanothus cuneatus*) in the middle of Douglas-fir forest; and rocky ridges where repeated lightning fires perpetuate the dominance of tan oak.

I never trapped this mouse in virgin coniferous forest. Yet young individuals undoubtedly dispersed through that unfavorable habitat, for the species occupied some cutovers surrounded by dense forest within a year or two after logging.

Townsend chipmunk.—The Townsend is the only one of the western chipmunks that is able to live deep within a virgin forest, but like white-footed mice its numbers increase when logging replaces the trees with herbaceous and shrubby vegetation. This chipmunk is partial to cover; it avoids large tracts of bare ground. For that reason it is scarce or absent on many cutovers during the first year after logging. The amount of slash is the critical factor. If all of it, including logs, is removed, coniferous seed can be planted in the first fall with reasonable assurance that there will be no disturbance from chipmunks. But when a cutover is from three to ten years old, the population of chipmunks is likely to be two to four times larger than in the original forest. When a climax of tan oak is reached, chipmunks of this species disappear.

One of the common plants of cutovers is bull thistle (*Cirsium lanceolatum*). The seed it produces in abundance is a favorite of chipmunks. In the fall when the thistle-heads were ripening, animals from the forest invaded logged land to eat this food. The population build-up at that time, as indicated by live-trapping, was striking. Elimination of thistle would help control numbers of chipmunks on cutovers.

Since the Townsend chipmunk is able to live in the virgin forest where variety of food is limited, seed of the dominant plant, Douglas-fir, should be a staple food. But in the fall of 1952, at least, it did not seem to be sought by the animals. On a cutover where experiments were conducted with bait boxes, chipmunks that entered the boxes to eat walnut meat usually refused Douglas-fir seed, and seeds planted in the ground were not disturbed. Also, twelve stomachs from a cutover on which seed was falling in large amounts contained no trace of the seed and there was none in the cheek pouches of the animals. Yet artificial plantings of seed of ponderosa pine, which did not occur in the area, were quickly found and robbed by chipmunks.

Examination of 63 stomachs collected between May and September from virgin forest and cutovers suggested that hypogeous fungus, although important does not constitute as large a part of the diet as in the Sierra Nevada (Tevis, 1953). The percentage volume was 41 (frequency 62%). Insects rated 23 (52%), and seeds of herbs and brush, 32 (48%).

As in the Sierra Nevada (Tevis, 1955), the mating season of the Townsend chipmunk comes in the spring soon after the animals emerge from hibernation. Except at higher elevations, the sexual organs of all males examined after the middle of March had completely involuted. No pregnant female was taken later than the end of May and none in lactation after the end of July. Young of the year were first trapped in mid-July.

Hibernation begins in November, but some animals are to be seen until the end of the year even after snow falls. None was noted during January and February—the only months when seed of ponderosa pine is safe from chipmunks. But even then rare individuals emerge from their dens to make short explorations, for fresh tracks were found regularly throughout the winter in an occasional bait box.

Hibernators awaken in March, and by the middle of April all animals are active.

Sonoma chipmunk.—Because the Sonoma chipmunk does not inhabit virgin forest or cutovers, at least in the 2,000–4,000 foot altitude belt in the vicinity of Salyer, it is not a problem to foresters of that region. The only site at which it was trapped was a high rocky ridge covered with scrub tan oak and other brush—a habitat that was too dry to support Douglas-fir of commercial quality. No Townsend chipmunks were taken there. Ecological separation between the two species is fairly distinct. On South Fork Mountain at elevations of 5,000 to 5,500 feet, Miller (1944) observed that the Sonoma chipmunk occurred only along ridges in large, warm tracts of brush, while *townsendii* occupied the surrounding forest of red and white fir.

Trowbridge shrew.—In the Pacific Northwest the Trowbridge shrew feeds on seed of Douglas-fir and is common enough to be ranked among those mammals that hinder reforestation (Kangur, 1954; Moore, 1942). In the California Douglas-fir region this soricid is not sufficiently numerous to be a threat—especially on young cutovers where numbers of shrews are less than in the original forest. Even a cutover in the weed-brush stage does not support large populations, as it does of mice and chipmunks.

The breeding season apparently occurs in winter or early spring, for all of 45 males and 39 females collected from June through October were sexually quiescent. In the Sierra Nevada, Jameson (1955) took breeding specimens only between February and May.

Specimens molting from the brown pelage of summer to the black coat of winter were trapped in October.

Dusky-footed wood rat.—Wood rats depend on leafy vegetation rather than seed for food, and no evidence was obtained that the species is detrimental to reforestation. Rats that entered bait boxes did not eat Douglas-fir seed.

Wood rats do not live in dense coniferous forest, but because they like brush and slash they are common inhabitants of cutovers of all stages. They thrive also in dense stands of tan oak, where they are more numerous than any other species of rodent.

Bushy-tailed wood rat.—This animal requires moister conditions than are

favored by the dusky-footed species. It is rare in the Douglas-fir region but abundant in cutovers of the redwood belt immediately to the west.

Digger squirrel.—This species is not able to live in virgin forest. It invades cutovers but takes longer to become established than do mice and chipmunks. Roads may be the chief routes of invasion. On some logged areas squirrels are not present, presumably because of not having penetrated the surrounding forest. Once established, though, they often become abundant.

Unlike mice and chipmunks, the species can be eliminated completely from a cutover for a year or more through the use of poison (particularly Compound 1080) on cereal baits. There is no evidence, however, that digger squirrels are injurious to reforestation in the Douglas-fir region. Young animals appear aboveground in July.

Red-backed mouse.—The habitat of the red-backed mouse is virgin coniferous forest, but even there it is much less common than the white-footed mouse. The few specimens that were trapped on cutovers were found in close association with logs. Elimination of logs makes cutovers entirely unattractive to the species.

Flying squirrel and *shrew-mole.*—These two animals are inhabitants of the virgin forest and occur rarely on cutovers.

Chickaree.—This tree squirrel is fairly abundant along forest-edge and in logged areas that have not been clear-cut. Complete removal of trees from any sizeable tract of land will virtually eliminate the chickaree from the middle of the area. It does not search for seed on the ground and is not a threat to artificial seeding; but because it cuts great quantities of cones it greatly reduces the amount of natural seeding. Cone-cutting begins in early July, even when the endosperm of the seed is milky.

Gray squirrel.—The larger tree squirrel also takes cones of Douglas-fir but in lesser amounts. Being more commonly found in association with oaks, it does not appear to be an important factor in coniferous reforestation.

Brush rabbit.—The rabbit is rare in all habitats. Sometimes it is found on cutovers but never in the virgin forest.

SUMMARY

Logging of the forest causes an increase in numbers of white-footed and big-eared mice, Townsend chipmunks, dusky-footed wood rats, digger squirrels, chickarees, gray squirrels, and brush rabbits. It causes a decrease in numbers of Trowbridge shrews, red-backed mice, flying squirrels, and shrew-moles.

The species that become most numerous are white-footed mice and Townsend chipmunks. They are the animals chiefly responsible for failure of artificial seeding of conifers. Also, along with the chickaree they are responsible for the destruction of large amounts of naturally produced seed.

LITERATURE CITED

FOWLE, D. C. AND R. Y. EDWARDS. 1954. The utility of break-back traps in population studies of small mammals. Jour. Wildlife Mgt., 18: 503–508.

JAMESON, E. W., JR. 1955. Observations on the biology of *Sorex trowbridgei* in the Sierra Nevada, California. Jour. Mamm., 36: 339–345.

KANGUR, R. 1954. Shrews as tree seed eaters in the Douglas fir region. Oregon State Board of Forestry, Research Note No. 17.

MILLER, A. H. 1944. Specific differences in the call notes of chipmunks. Jour. Mamm., 25: 87–89.

MOORE, A. W. 1942. Shrews as a check on Douglas fir reproduction. Jour. Mamm., 23: 37–41.

STICKEL, L. F. 1946. Experimental analysis of methods for measuring small mammal populations. Jour. Wildlife Mgt., 10: 150–159.

TEVIS, L. P. 1953. Stomach contents of chipmunks and mantled squirrels in northeastern California. Jour. Mamm., 34: 316–324.

———. 1955. Observations on chipmunks and mantled squirrels in northeastern California. Amer. Midl. Nat., 53: 71–78.

TROUSDELL, K. B. 1954. Peak population of seed-eating rodents and shrews occurs 1 year after loblolly stands are cut. U. S. Forest Service, Southeastern Forest Experiment Station, Research Notes No. 68.

Department of Zoology, University of California, Davis. Received August 8, 1955.

NOTES ON THE LIFE HISTORY OF *NAPAEOZAPUS*

BY NORMAN A. PREBLE

General collecting and study of small mammals from central and northern New Hampshire has resulted in an accumulation of data based upon the capture of 221 specimens of *Napaeozapus insignis insignis* (Miller). Most of the collecting has been the result of brief and sporadic trips, chiefly to Pinkham Notch situated in extreme northeastern Carroll County, at an altitude of 2,025 feet. This mountain pass lies at the eastern base of the Presidential Range. However, a few trap lines were established at nearby points in the range where ecological conditions seemed favorable for the animal and were, at the same time, not unduly different from those within Pinkham Notch itself.

The general topographic, floral and faunal features are so well known as to obviate the necessity of detailed descriptions except as they seem to apply to this particular species of rodent. The Presidential and Carter ranges, whose slopes form the narrow defile known as Pinkham Notch, are irregularly sculptured by several ravines, with Tuckerman and Huntington ravines the most prominent. The forested floors of both ravines are occupied by several small streams that that have their origin from springs located on the upper slopes of Mount Washington. From here, they pursue steep and rocky courses through a dense forest growth composed predominantly of black and white spruce, balsam fir, and yellow birch. The edges of these streams, both within the ravines and those in Pinkham Notch proper, are lined with alders. The flora in Pinkham Notch consists of scattered black and white spruce and a more extensive growth of sugar maple, beech, and yellow birch that attains an average height of about sixty feet. The lower zone of vegetation consists of sapling sugar maples, yellow and black birches, and hobble-bush, while the normally moist ground supports isolated patches of ferns, grass, mosses and a profusion of ground hemlock, bunch berry, painted trillium, purple trillium and corn lily. Moss-covered, rotting logs

lie in profusion, attesting to the violent winds that lash the forest at times throughout the year. The litter averages about two inches in depth and consists of leaves and leaf mold which overlies a gravelly and very rocky mineral soil. The small mammal associates of *Napaeozapus* that have been collected here include: *Blarina brevicauda brevicauda, Sorex cinereus cinereus, Sorex palustris albibarbis, Microsorex hoyi thompsoni, Peromyscus maniculatus gracilis, Clethrionomys gapperi ochraceus, Zapus hudsonius* subsp., *Tamias striatus lysteri, Glaucomys sabrinus macrotis,* and *Tamiasciurus hudsonicus gymnicus.*

Measurements.—Average measurements of 40 adult males from New Hampshire are: total length, 234 mm. (253–230); tail vertebrae, 146.9 mm. (160–132); hindfoot, 31.5 mm. (33–30); ear from notch, 16.5 mm. (19–14). Average measurements of 42 adult females are: total length, 240.4 mm. (259–231); tail vertebrae, 148.7 mm. (159–138); hindfoot, 31.2 mm. (33–30); ear from notch, 16.5 mm. (19–15). The weight of 21 adult males, lacking hibernation fat, average 21.5 grams (26.8–16.3). The weight of 30 non-pregnant adult females, lacking hibernation fat, average 23.4 grams (31.5–18.3).

Methods.—No attempts to conduct significant census studies have been made to date, and accordingly the positioning of traps, their number, and the type set have varied considerably from time to time. For the most part, the usual snapback traps were employed. Occasionally Climax and Cyclone traps were used effectively by baiting them with bacon rind. Traps of whatever design selected, were set singly in numbers varying from 20 to 150, spaced five steps apart. No attempt was made to select the most likely looking places. The experience that I have had in trapping mice in this area has favored the use of oatmeal almost exclusively as bait for any species of small mammal. At times I have used bacon rind and rubbed traps with beaver castors in addition to the oatmeal, but no significant increase in the catch was ever noted to be the result of such procedures. The use of oatmeal has been very successful, but it becomes useless as an attraction after it becomes wet. This usually necessitates rebaiting each trap after a rainstorm. Before the traps are positioned, a space about a foot square is cleared of leaves and sticks down to the soil level. This assures normal operation of the traps and may attract small mammals to the disturbed area. Quite often jumping mice are caught by the tail or by one hindfoot, and unless one wishes to hunt amid leaves and ferns for lost traps, it is better to secure them.

The number of small mammals that can be collected is considerably increased by visiting the trap lines after dark. Woodland jumping mice begin their nocturnal activities at this time and a trap's effectiveness can be considerably augmented by removing captured animals and resetting them again. I have collected and prepared 75 small mammals in a week by following such a procedure. The snapping of traps within hearing distance of a campsite may signal the proper time for a line check.

Habitat.—*Napaeozapus,* in this portion of its range, attains greatest population numbers within grass, sedge, and alder-lined borders of small streams where alluvial deposits of sand and gravel and accessible accumulations of forest duff permit easy construction of their burrows. Occasionally they may be trapped a

hundred feet or more from permanent water sources where moist plots of sedges and grasses occur within the forest. They have also been taken from the edges of boreal bogs, but I have never secured any specimens from the inner *Sphagnum-Larix* zone even though food and cover requirements appear to be met. There is no doubt that *Napaeozapus* is associated with water, but until more is known of the environmental requirements of these mice, it is useless to hazard guesses as to the factor or factors determining habitat selection. Their short, weak forelimbs would argue for a habitat in which burrows could be made with a minimum of effort. Cover requirements and the degree of cover utilization may also be important factors. I observed one animal foraging within a growth of *Carex*. When disturbed by my movements and the flashlight, it retreated into a clump and remained motionless until captured by hand. Additional observations of a similar nature are of great importance in the final determination of habitat requirements.

Hamilton (Amer. Midl. Nat., 16: 187–200, 1935) found in central New York, that *Zapus* was not infrequently caught in *Napaeozapus* territory but the converse did not occur. My observations in New Hampshire support these findings completely and it would appear either that the two genera have distinctly different habitat requirements, or intergeneric intolerances of some sort might be indicated.

Napaeozapus extends its distribution via small streams well up the forested slopes of the Presidential Range to sub-alpine areas. On August 6, 1938, Alfred E. Preble and myself set out ten traps at an altitude of approximately 4400 feet on the "fan" in Huntington Ravine. This is a boulder-strewn V-shaped slope partially covered with vegetation, with its apex located immediately at the base of the headwall. At the same time, 29 additional traps were set in the Alpine Garden just beyond the rim of the headwall. This latter site is about 650 feet higher than the trapping sites on the fan, and marks the highest limit of tree growth on this particular aspect of the Presidential Range. The following morning a single specimen was collected on the fan. No specimens were taken in the Alpine Garden. Again, during August, 1952, two short lines of ten traps each were set on the headwall itself. The first began immediately above the point where the Huntington Ravine Trail crosses the ledges, at an altitude of about 4500 feet. The second line of ten was placed at an altitude of approximately 4900 feet. Two specimens were taken, one in the lower set of traps and one in the upper group. I do not consider these two high-altitude records to be exceptional but rather that it is quite possible that the woodland jumping mouse makes its way quite generally to such altitudes and resides permanently wherever food, cover and easy digging conditions permit.

Carolyn Sheldon (Jour. Mamm., 15: 290–300, 1934) noted a colonial pattern in the local distribution of *Napaeozapus* at Lake Kedgemekoogee, Nova Scotia, but I have failed to find evidence of this in northern New Hampshire. At Center Ossipee, 50 miles south of Pinkham Notch, suitable habitats for *Napaeozapus* are definitely isolated from each other and, accordingly, captures would suggest colonialism. In more favorable conditions, such as those found in Pinkham Notch, this colonial pattern is not evident so far as present studies have gone.

Breeding.—Napaeozapus has been collected from the vicinity of the Presidential Range from early May to mid-October. From these specimens there has been assembled records of breeding which, when combined with those of Hamilton (*op. cit.*) and Harper (New York State Handbook, No. 8: 51–118, 1929) for New York, Sheldon (Jour. Mamm., 19: 444–453, 1938) in Vermont, and information recorded on museum specimens collected by Glover M. Allen, Alfred E. and Edward A. Preble, Arthur H. Howell, and Francis Harper from New Hampshire, shows a regular occurrence of pregnancies from the latter part of May to the latter part of August. At Pinkham Notch, breeding may occur in May, for six pregnant females caught between May 25 and May 29, 1952, contained embryos ranging in size from 1 mm. to 14 mm. C. R. length. The latest record of pregnancy was a single specimen collected on August 27, 1947 at Pinkham Notch. This female had five 14 mm. embryos. The occurrence of pregnant females in August is further attested to by Glover M. Allen who obtained a female at Kinsman, New Hampshire on August 22, 1927, which had six embryos of unrecorded length. Litter size as determined by embryo counts on 14 females from New Hampshire varied from four to six. The largest embryo measured was 20 mm. C. R. length. The total length of newborn young is 42 mm. (Hamilton, *op. cit.*) and the smallest specimen that I have trapped measured 190 mm. The absence of females containing embryos larger than 20 mm., and the absence of very young animals from the records is suggestive that females in advanced pregnancy are not active, nor are the young abroad until they are well grown. The apparent continuous appearance of pregnant jumping mice from the latter part of May to the latter part of August is doubtless misleading. These data are from different years and therefore reflect different environmental conditions operative from year to year. J. P. Schooley (Jour. Mamm., 15: 194–196, 1934) found that the normal breeding cycle of *Tamias* may be considerably affected by periods of inclement weather falling within the gestation period. This resulted in the absorption of embryos. Such females later became pregnant and therefore were out of phase with normal estrous cycles. Further studies are needed to clarify this problem.

Hibernation.—Three trips have been made to the Pinkham Notch area specifically to determine the time of emergence in the spring. The first was made from May 29 to May 31, 1952, at which time a series of 15 males were trapped. Nine of these had an average total length of 218 mm. (227–190 mm.). A second trip was made between May 13 and May 15, 1955. Eleven more were secured—again all males that had an average total length of 226 mm. (243–208 mm.). The last study was made two weeks later, from May 27 to May 29, 1955. At this time, 21 specimens were collected that showed an essentially equal sex ratio and a typical diversification of sizes. Between September 25 and October 2, 1937, 35 specimens of *Napaeozapus* were trapped at the same locality. Twenty were males and 15 females. Only eight of this series were fat, and their average weight was 30.3 grams. The remaining 32 mice had no pronounced accumulation of fat. These had an average weight of 19.1 grams. (25.3–12.5 grams). Fifty per cent of these were considered immature animals—an unusually high percentage.

At the present time only a tentative analysis of these data can be made. The

presence of immature males, at a time that cannot be long after spring emergence, suggests that they may precede the appearance of both immature and mature females and the adult males. The trapping of small males shortly after spring emergence was not to be expected unless there is a preemergent breeding season, which seems unlikely. The unusually large percentage of immature animals trapped in the fall of 1937 implies that it might be this group that enters hibernation after the adults, and are the ones that emerge first the following spring. Tagging studies are needed to confirm this supposition. If such be the case, then it follows that there is little, if any, increase in physical proportions during the six months that these immature rodents spend in hibernation.

Effort thus far made further suggests that these animals are very sensitive to microclimatic variations that affect not only the duration of hibernation but also the time of emergence and entrance as well. Accordingly no specific calendar time can be assigned when these events take place. It is expected that future studies will show that emergence may occur as early as the latter part of April in some years or as late as the middle of May in others. Entrance into hibernation would be similarly affected. This might occur the first week in October; at other times as late as the first of November.

Summary.—This study was based on 220 specimens of *Napaeozapus* collected in the Presidential Range of the White Mountains, New Hampshire, from 1933 to 1955. The preferred habitat occurs along the wooded edge of streams where alluvial deposits of sand and gravel and accumulation of duff offer both ease of burrow construction and protection. Altitudinal distribution extends to 4900 feet. No evidence of colonialism is evident. Climatic factors are thought to be responsible for variations from year to year in times of emergence and entrance into hibernation, and for variations in the reproductive cycle. Litter size varies from four to six. The young are not active until well grown. Immature males precede both immature and mature females and mature males in emergence. Immature, non-fat *Napaeozapus* active during October are presumed to enter hibernation later than the adults, and it is believed that males of this group of late fall entrants emerge first in the spring. Adult females are slightly larger and heavier than the males.

Department of Biology, Northeastern University, Boston 15, Massachusetts. Received June 11, 1955.

MOLT IN THE POCKET GOPHER, *THOMOMYS BOTTAE*

By G. Victor Morejohn and Walter E. Howard

This paper is an attempt to establish the sequence of molt patterns and the number of annual molts in pocket gophers from Davis (*Thomomys bottae navus*) and O'Neals (*T. b. mewa*), California. Investigations were conducted between 1949 and 1955 and were based on laboratory and field studies of more than 600 animals. Histological aspects of hair development are also described herein.

Acknowledgements are extended to Jay C. Quast, Nathan W. Cohen, and Henry E. Childs, Jr., for aid in live-trapping and in recording field molt data. Mr. Childs also prepared most of the flat study skins. Seth B. Benson and Robert L. Rudd are gratefully acknowledged for their comments on the study and for reading the manuscript.

METHODS

Live-trapped gophers.—Pocket gophers (*T. b. mewa*) were periodically live-trapped on a 3.7 acre plot at the San Joaquin Experimental Range, O'Neals, San Joaquin County, California, from 1949 to 1954 (Howard and Childs, MS). Each time an animal was captured, the position of any molt line present (where visible) was recorded on 5 x 8 inch cards containing mimeographed outlines of dorsal and lateral views of a gopher. The pelage color and also the comparative length of hair, if apparent in the two seasonal pelages of molting gophers, were also entered on the card. A total of 789 of these recordings was obtained from 198 individuals. Fourteen gophers living on the plot were dyed as an additional procedure, but this was at a time when trapping was less frequent. Nevertheless, during the ensuing fourteen months, ten of the dyed animals were recaptured a total of 21 times.

Kill-trapped gophers.—Flat study skins were prepared from 355 gophers trapped on and around the study plot at the Experimental Range. Only a few skins were obtained from June to September—the season when rangeland gophers show little evidence of surface activity and are difficult to trap. The area of pigmentation on the flesh-side of the skins, indicative of follicular activity, was measured with a planimeter. Similar measurements were also made of the area of each skin that was in summer or winter pelage. The position of molt lines and other data were also obtained from nearly 100 animals collected from irrigated alfalfa fields at Davis.

Dyed and bleached gophers.—A technique of dying hair black and of bleaching black hair to light brown was developed by the senior author and D. G. Constantine in 1949 (unpublished). The technique had been employed on studies of molt in cattle and swine, and it was found applicable to other mammalian species as well.

To dye the animals, a black human hair dye with an oil base was used. Since it was not water soluble, the dye persisted until the hair was shed. It was diluted with an equal amount of 30-volume (3%) hydrogen peroxide. Granulated soap was added until a thick liquid was obtained. The soap made application easier,

saved dye that would have otherwise run off the gopher, and shortened the time of dye action to 15–20 minutes per animal—half the time otherwise required.

Animals were anesthetized with ether, then the dye was applied with a toothbrush. Little dye was applied to the head, for when the animal regained consciousness, it invariably began to clean itself. In so doing, it spread the dye over its head. Application of the dye required approximately five minutes. After the action of the dye was complete, surplus dye was washed off. Excess water was carefully pressed from the hair. The animal was then placed in a container partly filled with cornmeal. Even though each animal attempted to dry itself by pushing through the cornneal, to hasten moisture absorption additional cornmeal was also poured over the drying animal.

A similar procedure was followed for the bleach method. Ammonium hydroxide (4%) was used in place of the dye in a ratio of one part to two parts hydrogen peroxide. The general appearance of bleached gophers was a lighter brown. The bleaching was most effective on the basal portion of the hairs in distinguishing bleached from unbleached hairs. Molt on bleached animals could only be discerned by blowing hair aside in order to check presence of slate-colored basal portions of new hair.

The dye method was superior to bleaching. Untreated emerging hair was clearly evident on dyed gophers. The bleach method works better on animals having black pelages.

Laboratory procedures.—Four gopher outlines (dorsal, ventral, and two lateral views) were mimeographed on 8½ by 11 inch paper for recording molt progression. Drawings of position of molt lines prior to dying or bleaching were made, and subsequent molt patterns were recorded as often as necessary, usually about every two weeks.

All laboratory animals were housed in open-topped, metal-sided cages, with wood shavings as litter. Water was supplied at all times in small dishes or bottles. The bulk of the food consisted of commercial rabbit pellets and rolled oats, but occasionally carrots or potatoes were provided. Temperatures in the laboratory ranged from 16 to 30°C.

MOLT PATTERNS

Most mammals molt completely, annually or semi-annually. Usually, hair is not shed and regenerated over the entire body surface simultaneously, (exceptions are found in young mammals) but begins at one or several places and spreads over the rest of the body. During this process, part of the coat is composed of new hair, and the remainder is composed of old hair. The configurational relationship between old coat areas and new coat areas is referred to as a "molt pattern." "Molt lines" appear where two seasonal pelages of different color and hair length meet or as a demarcation between two portions of a similar pelage that molted at different times. "Molt" may indicate either an active or a passive process. During the occurrence of follicular activity, an animal is actively molting. In passive molt there is cessation of follicular activity, and no pigmentation is visible on the underside of the skin; yet the animal's coat contains parts of more than one seasonal pelage.

Few detailed studies have been made of molt patterns in mammals. Studies of Bassett and Llewellyn (1948, 1949) on silver fox and mink are noteworthy. More recently, Whiteley and Ghadially (1954) studied molt and molt patterns in domestic rabbits by a method of dying hair black. It is of interest that the molt patterns they picture for the domestic rabbit are strikingly similar to those presented in this paper for the pocket gopher. Types of molt patterns in ground squirrels have been demonstrated by Hansen (1954). Cyclical waves of hair regeneration, in which one hair at a time is produced in a follicle, have been demonstrated for the laboratory mouse by Dry (1925–26) and Wolbach (1951), and the same for the laboratory rat by Haddow *et al.*, (1945), and Durward and Rudall (1949). Hair replacement in these animals usually begins ventrally and gradually spreads dorsally and posteriorly. Molt patterns in deer mice (Storer *et al.*, 1944) resemble those of the laboratory rat and mouse.

Nine gophers dyed black and one bleached were observed intensively for a year in the laboratory. At the time of capture all but two of the ten animals possessed one or two molt lines on their backs (Fig. 1, Top). How many of these lines represented active molt and how many passive molt is not known. Only one female (No. 63) continued to molt after being brought into the laboratory, and this molt was on the rump. Other gophers ceased molting in the laboratory for unknown reasons. Nevertheless, all animals started a new molt within four weeks after being dyed.

Fourteen animals living on the study plot were dyed early in February. Gophers there usually begin molting into summer pelage at this time. Two of the 14 had started to molt on the head before they were dyed. One of these was retrapped 88 days later, when about half molted. The area on the head, which had molted just before being dyed, had not remolted. Eight were recaptured 36 to 42 days later. Some of these individuals had lost as much as 80 per cent of their winter pelage in that time, whereas others had lost less than ten per cent. Several dyed gophers were caught twice between the end of March and May; and during this period little additional molting had occurred, and none of them had molted on the rump. No dyed hair was present on one animal caught 10 months later and on two animals trapped 14 months after being dyed.

A series of molt pattern progressions in an individual pocket gopher is demonstrated in Figure 1, Bottom. Molt usually started on the feet and head. The tail generally started to molt several days later, but occasionally molt commenced in all three places simultaneously. Sometimes it took place on the nape of the neck or midventral area before beginning on the head or tail. With one individual the tail was the last area to molt. A composite picture of progression of molt was obtained (Fig. 2). However, it should be pointed out that there was much variation in pattern and rate of molt. Figure 2 should be referred to for the following description of molt.

Active molting on the head began with several spots of new hair around the eyes or ears. On the tail it usually began at the tip and progressed toward the body. Molt on the forefeet advanced dorsally to unite with other areas of new hair. Hind and forefeet often molted in narrow bands. This type of molting usually began at the toes and progressed toward the elbow. At this stage of molt

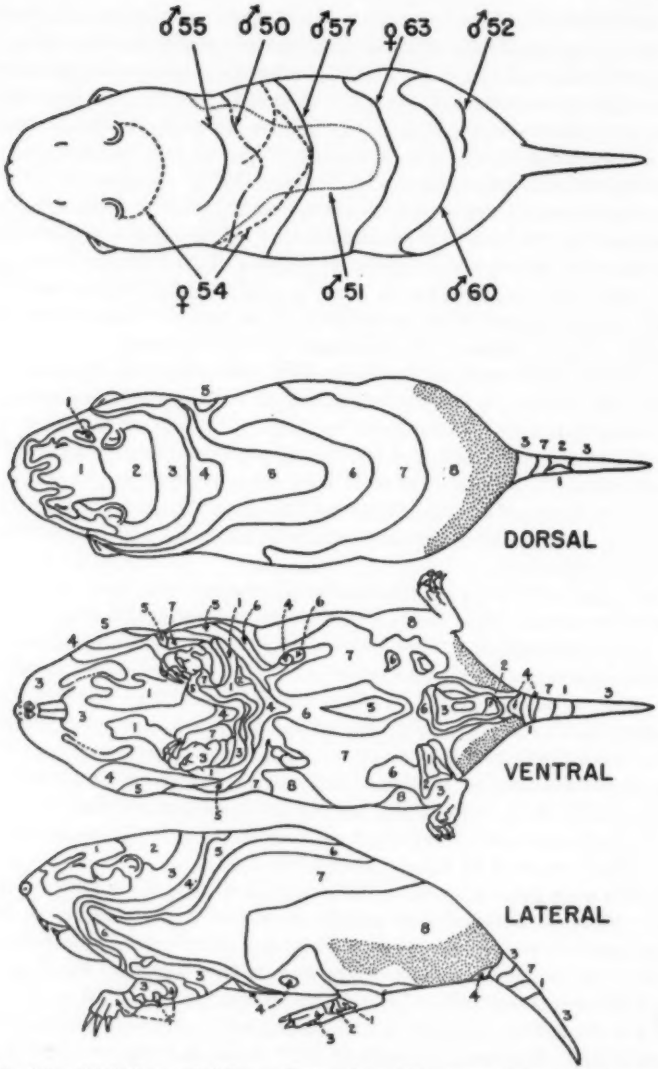


FIG. 1.—TOP: Molt lines of eight pocket gophers (*Thomomys bottae navus*) represented on one drawing (dorsal view). These eight animals were live-trapped during the period January to April, 1952, and the state of molt was recorded individually.

BOTTOM: Three views of detailed patterns of progression of the second laboratory molt on female pocket gopher no. 63. Successive recordings are numbered 1 to 8 and were taken at intervals of 19, 7, 20, 8, 14, 23, and 20 days, respectively. Molting stopped after region 7 molted. Eleven months after being dyed, the animal was killed. At this time the stippled portion of region 8 was still not molted. Regions of more complex spot-molting around the head and ventral surface are not all numbered in this illustration.

the overall effect was that of striped legs (Fig. 2, lateral B), but this pattern eventually was lost as areas of new hair fused together.

Molt around the eyes and ears expanded over the head in all directions, and molt between the fore legs continued anteriorly along the throat and jaw to the chin. The area around the nose molted and fused with the rest of the new hair of the head. While molting of these areas progressed, spots appeared along the abdomen, and streaks of new hair developed along the mid-line of the ventral side of the body. At this time the forefeet had molted up to the elbows, and a continuous line was often visible running dorsally from the ventral surface of the elbow and anteriorly along the edges of the cheek pouches (cheek pouches were not dyed, thus their molt was not observed). As this line reached a point below the eye it turned dorsally, then posteriorly and progressed below the ear gradually

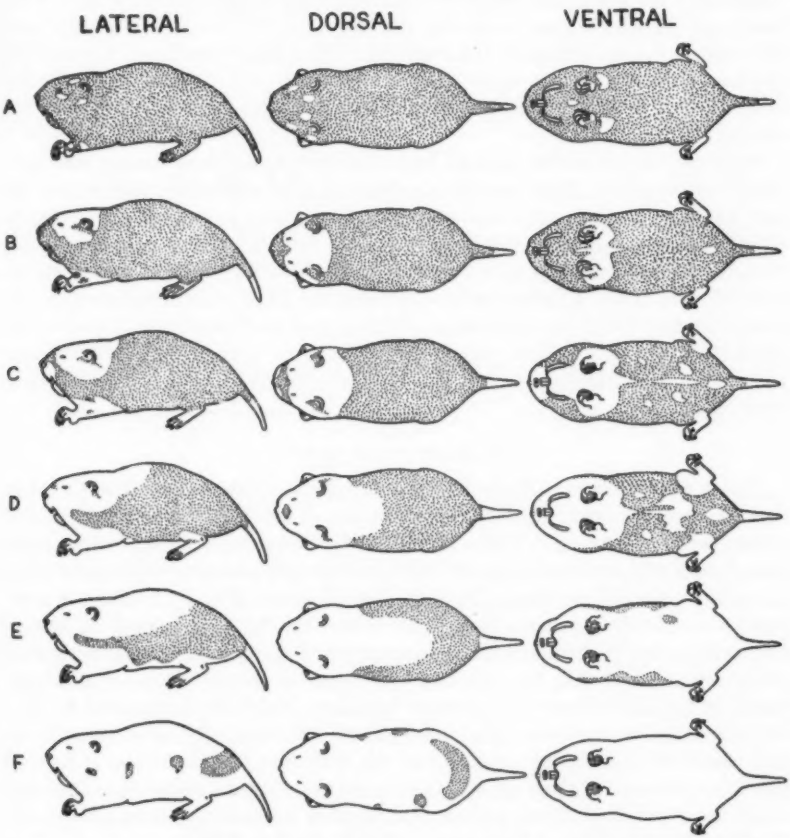


FIG. 2.—Major stages of molt pattern progression in the pocket gopher (*Thomomys bottae navus*) at Davis. Stippled areas represent hair dyed black; white areas represent new pelage that has replaced dyed hair. See text for details.

curving dorsally behind the head (Fig. 2, lateral D). The line continued a similar course on the opposite side. On an un-dyed gopher this line can clearly be seen dorsally; however, it cannot be seen in its entirety elsewhere unless the animal is dyed.

Along the abdomen the spots and streaks of new hair expanded and fused together. Dorsally the molt line moved posteriorly more rapidly than on the sides. The location of the original molt line along the dorsal surface of dyed gophers (Fig. 1) apparently affected the next molt. Progression of hair replacement posteriorly ceased just short of these lines. Within a few days molt continued from the posterior side of the old molt line leaving unmolted areas of various sizes in front of the original molt line. Eventually these areas also molted. The remaining dyed hair on the gopher at this stage (Fig. 2, dorsal E) was roughly a "lyre-shape" (Applegate and Predmore, 1947) with its ends lying laterally on each side of the head, and the curved part extending laterally along the body and dorsally over the rump. As molt continued, the ends and sides of the "lyre-shape" were gradually broken into irregular spots which later disappeared. Last to molt was the rump and one or two small lateral spots. In general, molt patterns were somewhat similar on all gophers.

Six of the ten laboratory animals began a second molt before the first was completed on the rump. They were then redyed. It is of particular interest that the pattern of the second molts showed a striking parallel to the preceding ones in their progression patterns and in manner of molting around the eyes. Also, the regions of the old original molt lines seemed to have the same influence on the time of molt of the adjacent areas. Although the lines were obliterated by the first laboratory molt, the progression of the second molt pattern in this area was similar to the first laboratory molt. This type of molt behavior may also have occurred in field animals, for they also showed molt lines and had irregular molt progression.

FREQUENCY OF MOLT

Pocket gophers from O'Neals display fairly distinct seasonal pelages, the summer coat usually being lighter colored, redder, and often consisting of shorter hairs than the winter coat. This was not clearly evident on some specimens, however. The winter coat was acquired rapidly in the fall, and nearly all gophers had a complete winter coat during December and January (Fig. 3). Females started acquiring a summer pelage sooner than males but did not complete it sooner. Pigmented areas on the flesh-side of skins appeared nearly a month before summer pelage was evident (Fig. 3). After females began molting into a summer pelage, breeding began (February). Following breeding (May) there appeared to be a distinct delay in completion of summer pelage. Kill-trapped pregnant females at this time had considerable pigment on the flesh-side of their skins. It seemed possible that some of them were obtaining part of a second winter coat, but this could not be verified. Dyed gophers retrapped in the field also were slow in obtaining summer pelage, at least during March, April and May.

Few skins were available for the period from May to September. This is the

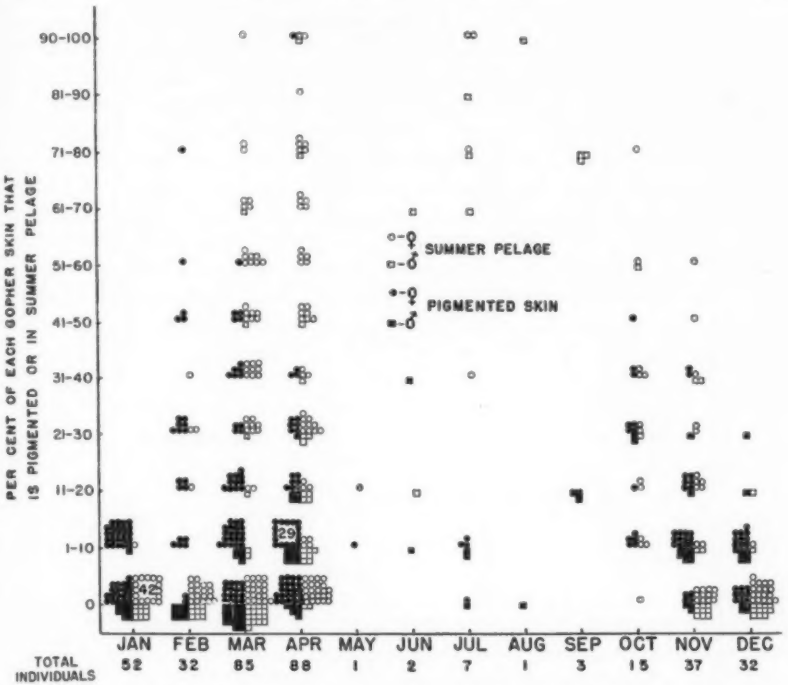


FIG. 3.—Scatter diagram based on 355 flat skins of the pocket gopher (*Thomomys bottae mewa*) from O'Neals. Each skin is plotted twice during month captured; once with regard to percentage of summer coat present and once with regard to percentage of pigmented area occurring on the underside of the skin. Follicular activity usually preceded pelage change by approximately one month.

time of year when gophers are less active and difficult to trap. The evidence at hand, however, indicated that a *complete* summer coat seldom occurred, and, when it did, lasted for only a brief period. New winter pelage frequently began to appear before the summer pelage had replaced the previous winter coat on the rump. Bailey (1915) also found winter coats to be acquired more rapidly in the gophers he studied.

The frequency of gophers undergoing all stages of molt throughout the year on the study plot is shown in Fig. 4, Top.

Skins from small juvenile animals, in most cases, showed hair replacement occurring over the entire body simultaneously. The soft, grayish coats also seemed to be replaced more rapidly than adult coats. At O'Neals the first adult pelage was a summer coat. It is possible that with some subadults, an adult winter pelage was acquired on the rump before the juvenile pelage in that region was replaced by a summer coat.

Duration of the major part of the molt of laboratory gophers from Davis

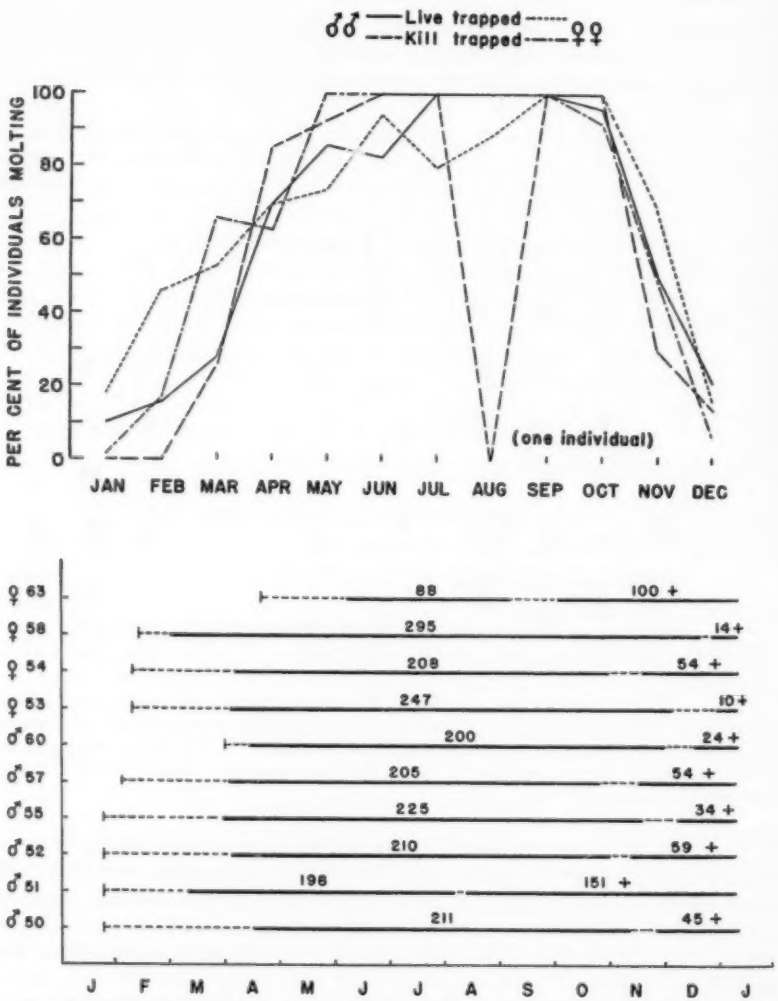


FIG. 4.—TOP: A comparison is made between skins (*Thomomys bottae mewa*) of 355 kill-trapped animals and 789 recordings from 198 live-trapped gophers. The percentage of animals that were molting or possessed both a summer and winter coat are plotted by month. The winter pelage was acquired more rapidly than the summer coat.

BOTTOM: Duration of molting of most of the pelage in pocket gophers (*Thomomys bottae navus*) from Davis. Vertical lines indicate time of capture, and dashed lines indicate no molting activity. Solid black lines represent the number of days taken to molt the dyed pelage (exclusive of rump region in some), or part of a second molt in progress. Numbers above lines represent approximate days of molting activity. All gophers except ♂ no. 52 were dyed black. Male 52 was bleached, and the actual date of onset of the second molt is only an approximation.

ranged from 88 to 295 days with an average of 208.7 days per animal (Fig. 4, Bottom). These figures were obtained by considering a molt finished as soon as another one started. With other dyed gophers the rump region retained dyed hair after another molt had begun on the head and feet. Molting of this patch of dyed hair was not consistent. In some individuals the patch was molted soon after beginning of the second molt, but on other occasions the rump patch would not be molted during the second molt; and the old dyed hair would be retained until replaced by a third molt. Two laboratory gophers, a male and a female, retained dyed rump hairs after periods of 17 and 18 months. Five animals retained dyed rump hairs for at least one year. It follows that occasionally the rump region molts only once a year, although the rest of the animal may molt twice a year. Such animals, therefore, may possess simultaneously: (1) original dyed hair on rump; (2) a coat produced by the first laboratory molt over the bulk of the body; and (3) new hair on the head, tail or feet replacing (2) above. Although laboratory and field animals, in most cases, possessed no more than two coats at the same time, it was clearly demonstrated with dyed gophers that sometimes there were parts of three coats present. Evidence was found that this manner of molt also appeared in wild gophers. Bailey (1915) mentioned that this manner of molting occurred in high or northern localities in other species of gophers, but he did not determine if the rump region molted once or twice a year.

HAIR DEVELOPMENT

Types of hair morphogenesis in mammals have not been adequately studied. The manner of development of single hairs from individual follicles is clear (Butcher, 1951; Noback, 1951), but variations that exist deserve mention. In the chinchilla, hairs emerge from skin pores (follicles) that contain 60–70 individual hairs (Wilcox, 1950). Each hair has its own follicle, and each cluster of hairs consists of one guard hair and many wool hairs. Collectively, the cluster of follicles is called a compound follicle. In general, this type of hair development was found in the pocket gopher. In the gophers studied the total number of hairs in each compound follicle ranged from 8 to 19.

Molting and non-molting gopher skin (*T. b. navus*) was studied microscopically. Pieces of skin were fixed in Bouin's fluid and in Newcomer's fluid (Newcomer, 1953). Serial sections were cut at ten microns and stained with Harris' hematoxylin and eosin. Cross and longitudinal sections were made to reveal the pattern of follicular arrangement and growth (Pl. I). There was little evidence, in the material examined, of lingering hair germs in the derma or in the stratum subcutaneum. New follicles probably develop from cells at the bases of old hair follicles. As the new follicles begin to develop, growth takes place downward through the derma. Contact with the paniculus carnosus muscle of the skin (Pl. I, Bottom) may occur with formation of hair within, and elongation, of the follicles. New follicles, lying almost parallel to the surface of the skin, organize into small bundles, and the developing hairs grow upward and emerge through an old compound follicle. Each new hair grows between the old hairs. Old hairs begin to fall out when new hairs are about two thirds grown externally.

Counts were made of numbers of compound follicles within an area of skin

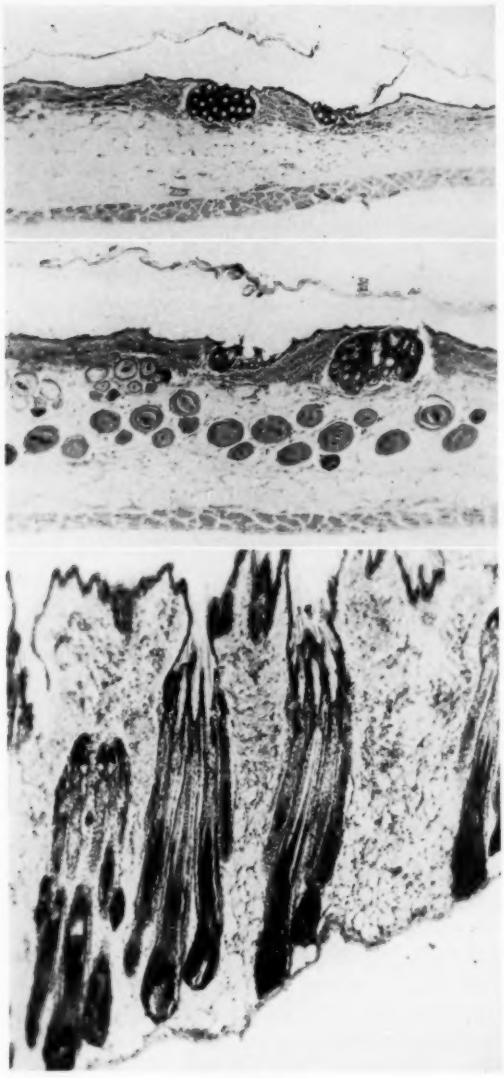


PLATE I

TOP: Cross-section of non-molting skin of pocket gopher (*Thomomys bottae navus*). A complete compound follicle is visible in the dermis consisting of 18 individual hair follicles. Adipose tissue of subcutaneum does not show evidence of inactive hair germs. Tissue was fixed in Bouin's fluid, and serial cross-sections were made at 10 microns. The stain used was Harris' hematoxylin and eosin.

MIDDLE: Cross-section of molting skin of pocket gopher (*Thomomys bottae navus*). No new hairs have erupted through the skin at this stage. Developing follicles can be seen in the subcutaneum, and part of an old compound follicle can be seen in the dermis. Preparation same as above.

BOTTOM: Tangential longitudinal section of actively molting skin of pocket gopher (*Thomomys bottae navus*). The compound nature of the hair follicles is clearly visible. The hair bulbs, undergoing active mitoses, are seen to extend through the subcutaneum to the paniculus carnosus muscle of the skin. Tissue was fixed in Newcomer's fluid, and serial sections were made at 10 microns. Tissues were stained in Harris' hematoxylin and eosin.

5 mm.[2] from the region of the mid-back of *T. b. mewa*. The following figures represent average counts on two animals in each of the following classifications: adult ♂♂ winter pelage, 131 compound follicles; adult ♂♂ summer pelage, 118; adult ♀ ♀ winter pelage, 171; and adult ♀ ♀ summer pelage, 166. Counts were accurately made, but the degree of stretch and shrinkage was probably not the same for each skin. A real difference seems to exist in density of follicles between males and females, but much additional data are needed before conclusions can be drawn.

DISCUSSION

Bailey (1915) was the first to describe what he considered to be the typical molt for the genus *Thomomys*. His description of the molt was based on a large series of conventional round study skins. The conclusions presented herein differ from Bailey's in several major aspects. The points of difference stem primarily from examination of the pigmentation on the flesh-side of gopher skins, prepared as flat skins, and from observations made on living gophers. One or more molt lines observed by Bailey on a gopher skin led him to assume that several "waves" of molt were taking place. If this were true, a gopher replacing its winter coat would have molted as many as five times or more before its full summer pelage was assumed. Material examined in the present study demonstrated that what may appear to be a molt line may indeed be only an area that ceased molting for a time. Since a new coat may appear in an irregular fashion, several molt lines may be present at the same time. In discussing the fall molt, Bailey (*op. cit.* states that this molt ". . . seems not to replace the first but to fill up and thicken the coat, while both (coats) may increase in length as the weather becomes more severe." Five pocket gophers (*T. b. navus*), which had been dyed previously, were placed in a cold room at 40 degrees Fahrenheit. During a period of approximately five months some molting activity took place, but there was no development that could be attributed to the colder environment. Hair did not grow longer, and old coats did not become denser. It is not known if gophers in a colder climate would behave differently.

In describing hair development in the young gopher, Bailey accurately described the first juvenile coat, but due to lack of critical material, he was unable to interpret correctly subsequent molts. Observations based on several skins of very young animals and on captive young (litter mates) of approximately the same age indicate that hair replacement in young gophers is not unlike that of most young mammals studied by other workers. The first coat of fine silky hair is replaced simultaneously over the entire body by a longer silky coat. After acquisition of this coat (complete or incomplete depending on time of year), a juvenile coat begins to make its appearance in the region of the head and progresses over the body in a posterior direction, in a manner similar to that of the adults. Details of exact molt line configurations were not obtained, since young animals were not dyed. The flat skins from O'Neals suggested that subadult pelage on the rump may sometimes molt directly into a winter coat, but at other times all of the subadult pelage was known to have molted into summer pelage before the winter coat appeared.

Laboratory evidence of molt patterns in the pocket gopher presented herein need not necessarily be typical for all wild gophers. For a more thorough understanding of molt in wild populations, it is suggested that several dozen field animals be dyed and then retrapped for a year or longer at intervals of about two weeks. Subsequent redying with dyes of different colors should be done before a molt is complete to make sure that certain areas do not molt again before the remainder of the original coat is lost. This information is needed from gophers living at both low and high elevations so that there will be a marked difference in environmental temperatures.

SUMMARY

Observations of molt were made on more than 600 pocket gophers (*Thomomys bottae*) from Davis and O'Neals, California. One hundred ninety eight were repeatedly live trapped; nine dyed gophers and one bleached animal were examined periodically in the laboratory; 14 field animals were dyed; 355 flat study skins were analyzed; and nearly 100 other miscellaneous gophers were utilized.

The pattern of the progression of molt and the frequency of molt on different parts of the body were established. "Molt lines" sometimes appeared as lines of demarcation between two portions of a similar pelage which molted at different times; in addition, "molt lines" indicated boundaries between summer and winter pelage. Occasionally the rump region skipped a molt. Some animals possessed parts of three coats simultaneously. Rates of follicular activity differ in various parts of the skin. In general, molt patterns of all gophers were similar, but there was a certain degree of variation. Distinctive histological features of hair regeneration in the pocket gopher are described.

LITERATURE CITED

Applegate, V. C., and H. E. Predmore, Jr. 1947. Age classes and patterns of primeness in a fall collection of muskrat pelts. Jour. Wildlife Mgt., 11: 324–330.

Bailey, V. 1915. Revision of the pocket gophers of the genus Thomomys. North Amer. Fauna, No. 39: 1–132.

Bassett, C. F., and L. M. Llewellyn. 1948. The molting and fur growth pattern in the adult silver fox. Amer. Midl. Nat., 39: 397–601.

———. 1949. The molting and fur growth pattern in the adult mink. Amer. Midl. Nat., 40: 751–756.

Butcher, E. O. 1951. Development of the pilary system and the replacement of hair in mammals. Ann. N. Y. Acad. Sci., 53: 508–516.

Dry, F. W. 1925–6. The coat of the mouse. Jour. Genetics, 16: 287–330.

Durward, A., and K. M. Rudall. 1949. Studies on hair growth in the rat. Jour. Anatomy (London), 83: 325–335.

Haddow, A., L. A. Elsen, E. M. F. Roe, K. M. Rudall, and G. M. Timmis. 1945. Artificial production of coat colour in the albino rat, its relation to pattern in the growth of hair. Nature, London, 155: 379–381.

Hansen, R. M. 1954. Molt patterns in ground squirrels. Proc. Utah Acad. Sci., Arts and Letters, 31: 57–60.

Howard, W. E., and H. E. Childs, Jr. (Manuscript) Dynamics of a pocket gopher population.

Newcomer, E. H. 1953. A new cytological and histological fixing fluid. Science, 118: 161.

Noback, C. R. 1951. Morphology and phylogeny of hair. Ann. N. Y. Acad. Sci., 53: 476–491.

STORER, T. I., F. EVANS, AND F. G. PALMER. 1944. Some rodent populations in the Sierra Nevada of California. Ecol. Monog., 14: 165–192.

WHITELEY, H. J., AND F. N. GHADIALLY. 1954. Hair replacement in the domestic rabbit. Jour. Anatomy (London), 88: 13–18.

WILCOX, H. H. 1950. Histology of the skin and hair of the adult chinchilla. Anat. Record, 108: 385–398.

WOLBACH, S. B. 1951. The hair cycle of the mouse and its importance in the study of sequence of experimental carcinogenesis. Ann. N. Y. Acad. Sci., 53: 517–536.

Department of Zoology and Field Station Administration, University of California, Davis. Received August 18, 1955.

THE REPRODUCTIVE CYCLE OF THE FIELD MOUSE, *MICROTUS CALIFORNICUS*

BY GILBERT S. GREENWALD

The cricetid rodent *Microtus* has been studied extensively in recent years due to its widespread geographic distribution and to the cyclic abundance shown by most of its species. Reports are available on certain aspects of the reproduction of *Microtus californicus* (Hatfield, 1935), *M. agrestis* (Brambell and Hall, 1939), *M. pennsylvanicus* (Hamilton, 1941), and *M. guentheri* (Bodenheimer, 1949). With these exceptions, the remaining work is primarily concerned with the population dynamics of *Microtus*. The present report, based on work in the field and in the laboratory, describes some of the anatomical and physiological features of the reproductive cycle of females of *Microtus californicus* and emphasizes certain aspects in which *M. californicus* differs from other microtines or from other rodents.

The present study is based on dissection of 581 female *Microtus californicus* collected over a 21- month period from 1951 to 1953. Most of these animals were trapped in grassland adjacent to San Francisco Bay, near San Rafael, Marin County, California. Approximately 50 were kept in captivity. Appropriate reproductive tracts were preserved in Bouin's fluid, paraffin embedded by the dioxane method, sectioned at 10 micra, and stained with Delafield's hematoxylin and eosin.

A summary of the field data may help in placing the laboratory findings in proper perspective. *Microtus californicus* is polyestrous, breeding throughout the year. The major breeding season is in the late winter and spring months with a minor period of reproductive activity in the fall. During the rest of the year sporadic pregnancies occur. The mean litter size is 4.2 with a range from 1 to 9 embryos. However, there is considerable seasonal variation in litter size depending upon the age of the females. Pregnancy lasts 21 days (Hatfield, 1935), and the young can be weaned in 14 days. There is a postpartum estrus.

Follicular development.—The anestrous ovary measures less than 1 mm. Large follicles nearing ovulation are grossly visible as clear translucent bodies while younger follicular stages cannot be detected macroscopically. In the pregnant animal the corpora lutea are conspicuous pink bulges, and the ovary may measure

up to 6 mm. An interfollicular stroma is most obvious in the anestrous and proestrous ovary. The interstitial cells are never secretory in appearance. The pattern of follicular growth resembles that of many small mammals, and towards the end of the preovulatory phase parallels especially that of the ferret (Robinson, 1918) and the cat (Dawson and Friedgood, 1940). Large preinseminal follicles of *Microtus californicus* are between 500 and 600 micra and contain ova between 60 and 65 micra. As in numerous other species, growth of the ovum becomes slow at about the time of formation of the antrum in the follicle. In *M. californicus* the ovum shows little growth while the follicle is increasing from 200 micra to its maximum postcopulatory size (900 micra).

In large preinseminal follicles there is a large antrum with the ovum embedded in a compact cumulus oophorus. The nucleus is eccentric and the zona pellucida well formed. The granulosa at this stage has two distinct types of nuclei (Pl. I, A). The outer cells are columnar with their ovoid nuclei close to the basement membrane, whereas the nuclei of the inner cells are rounded and more vesicular. There is no systematic arrangement of the inner cells. The theca interna (Pl. I, A) is fibrous, but there are scattered groups of polygonal cells that are apparently secretory.

Ovulation.—The small list of known induced ovulators (only 6 species) is probably more a reflection of our ignorance of the reproductive physiology of wild mammals than it is the actual status in nature. The difficulty in determining whether an animal is an induced or spontaneous ovulator stems in large part from inability to get timed, controlled breeding with wild mammals. The only positive proof of induced ovulation is through copulation, or cervical stimulation, combined with data from unstimulated controls. Other lines of evidence though suggestive are not conclusive. Thus the failure of a wild female to ovulate in captivity may be due to dietary or psychological factors. Similarly, a prolonged estrous smear in an isolated female could conceivably be due to vitamin A deficiency.

Only one species of *Microtus* has been studied in relation to the method of ovulation. Bodenheimer and Sulman (1946) concluded that *Microtus guentheri* was an induced ovulator. The evidence for this statement was that ten females isolated for 50 days after weaning failed to show estrus, or, at autopsy, corpus luteum formation. In a second experiment 22 females of the same age were isolated for four to eight weeks and also failed to show any estrous changes. Nine other females were then placed with males. At autopsy up to 11 days later, five of them were pregnant and four showed neither pregnancy nor corpora lutea. Their conclusion was: "this suggests that corpora lutea are only formed in *Microtus* as a response to copulation." While interesting, the experiments do not furnish direct proof that *Microtus guentheri* is an induced ovulator.

Several lines of evidence suggested that *Microtus californicus* is an induced ovulator. *Microtus* has a postpartum estrus, as shown by the recovery of pregnant lactating females from the wild population. In examining a number of postpartum reproductive tracts, no trace of fresh corpora lutea were found. If *Microtus* is a spontaneous ovulator, newly formed corpora lutea would have been expected

in all of the tracts. To test this, a female was sacrificed three days following parturition. The ovary contained only large preinseminal follicles and the regressing corpora lutea of pregnancy.

Another factor that pointed towards *Microtus* being an induced ovulator was the prolonged cornified smear. Bodenheimer and Sulman (1946) state that *Microtus guentheri* never has an estrous smear. In *M. californicus*, estrous smears that are 100 per cent cornified may be found. The duration of estrous smears in several females that were followed before being sacrificed was 5, 7, 12, 13, 14, 16, and 21 days. The figures seem to indicate that most animals have a prolonged estrous smear that would last indefinitely.

Unmated females killed 13, 14 and 21 days after the initial discovery of cornified smears showed only preinseminal follicles. One female spontaneously went out of estrus after four days of cornified smears. When killed two days later, only atretic follicles were found.

The crucial experiment for proving induced ovulation is to isolate an estrous female for several days and then to mate her. At autopsy, the female should show ruptured follicles or indications of post inseminal changes in the follicles. This is not easy since an estrous female is uncommon among laboratory *Microtus californicus*. A second difficulty is getting the males to mate. The males soon lose their agressiveness in captivity and their reluctance accounts for most of the breeding failures.

Table 1 summarizes the reproductive histories of several females that show rather conclusively that *Microtus californicus* is an induced ovulator. The evidence seems strong, taken in conjunction with the previously mentioned unmated controls. Copulation was only observed in one instance. In the other cases, the males and females had to remain with each other for several hours before coitus occurred. As a result, the time span in which coitus might have happened is rather indefinite. In an attempt to overcome the uncertainty as to the time of mating, several females were cervically stimulated with a glass rod. This failed to elicit ovulation in any of the animals.

Time of ovulation.—Ovulation occurs less than 15 hours after mating. Female 4, killed 18 to 25 hours after coitus, had already formed hollow corpora lutea. More direct evidence of the time of ovulation is furnished by two females that were

TABLE 1.—*Reproductive histories that show induced ovulation*

Animal number	Duration of estrus before placed with male	Time after possible mating female killed	Remarks
683	5 days	7 to 36 hours	Female killed 7 hrs. after vaginal plug found; 2 ruptured follicles; other ovulations imminent.
7	14 days	48 to 72 hours	Almost solid corpora lutea; 16-celled tubal ova.
8	16 days	44 hours (motile sperm when first smear taken)	Cavity of c.l. almost obliterated; abnormal tubal ova.
4	12 days	18 to 25 hours	Hollow corpora lutea.

mated within 24 hours after the discovery of a cornified smear. These females were excluded from Table 1 because the short duration of estrus might misleadingly suggest spontaneous ovulation. One of them had already ovulated when killed 15½ to 18½ hours after being placed with a male and had 2-celled tubal ova. The other was killed 15 hours after mating, and the tubal ova contained male and female pronuclei.

Post copulatory changes in the follicle and ovum.—The changes that occur in the postinseminal follicle of *Microtus* can be reconstructed from the ovaries of several females. Ovulation is not simultaneous in all follicles of *Microtus*. Female 683 had two already ruptured follicles, other follicles in which the first polar body had been extruded, and some in which the nuclear membrane was still intact. Enders (1952) found a similar lack of synchrony in the mink. Following coitus in *Microtus*, the meiotic divisions occur. As in most other mammals, the first polar body is extruded before ovulation and the ovum leaves the follicle with the chromosomes aligned at the metaphase of the second maturation division. There is no appreciable size increase of the ovum after coitus.

The most striking changes in the granulosa involve the breakdown of the cumulus oophorus and the subsequent free condition of the ovum in the follicle. When the ovum separates from the granulosa, it carries with it two or three layers of the investing cumulus oophorus. These granulosa cells hypertrophy to produce an asteroid corona radiata, that differs from that of the ferret (Robinson, 1918) and the mink (Hannson, 1947) in that in *Microtus* the cells are blunter. The granulosa cells bordering on the antrum of postinseminal follicles break off and are reorganized into a series of rosette shaped balls. A similar rearrangement is found in the cat (Dawson and Friedgood, 1940).

The mural granulosa in late postinseminal follicles seems to be undergoing luteinization. There is a breakdown of the basement membrane and small wedge-shaped groups of the interna cells invade the periphery of the follicular epithelium (Pl. I, B).

Following coitus, the theca hypertrophies and the cells appear to be definitely secretory (Pl. I, B). The nuclei are clear and polygonal and are found in numbers throughout the theca in contrast to the scattered groups found in the preinseminal follicle.

After mating, the follicle puts on a final spurt of growth until a maximal size of 900 micra is reached. The incretion results primarily from an accelerated production of liquor folliculi. The result is an extremely large antrum filled with a glairy coagulum of liquor and granulosa cells.

The ovum at ovulation measures between 65 and 70 micra. Fertilization takes place in the upper portion of the oviduct and the second polar body is then extruded. Few sperm are ever found in the oviduct in contrast to the large numbers found in the detritus that clogs the uterus. By the time the 2-celled stage has formed, the zona pellucida has disappeared in most cases. The 2-celled stage lasts for considerable time, since it is the commonest stage encountered among tubal ova. Sixteen-celled tubal ova were found in one female, 48 to 72 hours after coitus.

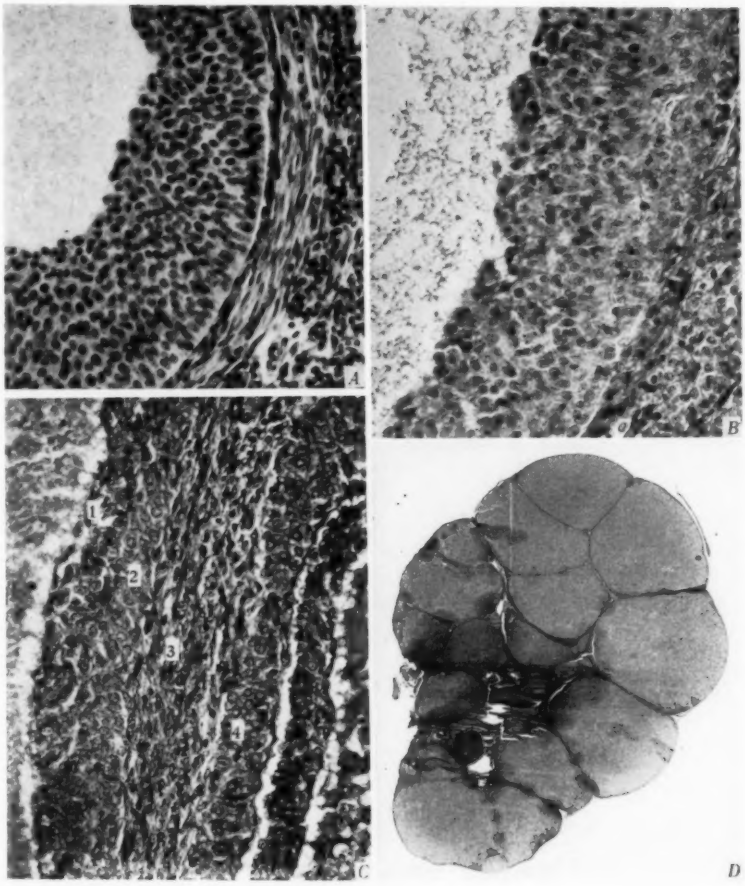


PLATE 1

A. The wall of a preinseminal follicle. The granulosa nuclei adjacent to the basement membrane are columnar in contrast to the polygonal shape of the inner layers. Enlarged cells are found in the theca interna, but in addition there are still a number of fibrous elements. 250×

B. View through the wall of a postinseminal follicle, prior to ovulation. The theca interna is hypertrophied, the basement membrane dissolving. 250×

C. View through the wall of a newly formed corpus luteum. Legend: 1. granulosa contribution to corpus luteum; 2. thecal luteal component; 3. theca externa; 4. thecal hypertrophy of an atretic follicle. 250×

D. Female 241. Ovary contains 17 corpora lutea, all of the same age. Total corpora lutea count was 29 for both ovaries. Note the spiral arrangement of the corpora. 13×

History of the corpus luteum.—Examination of newly formed corpora lutea indicates that both theca and granulosa cells are involved in the formation of the luteal cells (Pl. I, C), but by the time that clear-cut luteal cells are formed, the distribution of the thecal and granulosa components in the corpus luteum cannot be determined. As the corpus luteum continues to grow its cavity becomes reduced. One female had 2-celled tubal ova and corpora lutea that measured 1400 micra. The cavity was almost completely obliterated and the cells already had a luteal appearance but had not reached their maximal size. The corpora lutea are almost entirely solid between 48 and 72 hours post coitum. At these early stages of the corpus luteum, there are already differences apparent in the size of the nuclei. Some of the nuclei are two to three times the size of others. In the fully formed corpus luteum, these enlarged nuclei are indiscriminately scattered. It was not possible to determine whether they are of any physiological significance.

The individual luteal cells are first clearly secretory in tracts containing recently implanted embryos. There seems to be slightly more connective tissue in older corpora but otherwise little change occurs in the corpus luteum until parturition. There is a steady increase of the size of the corpus luteum throughout pregnancy. The largest corpora lutea measured were 2800 micra in diameter; 2000 micra is the average size reached in late pregnancy.

The corpus luteum is secretory throughout pregnancy. By three days after birth, involution has begun, secretion, judged by histological appearances, has ceased, and connective tissue is more apparent between the cells. A female killed 21 days after parturition had corpora albicantia that appeared grossly as white ½ mm. bodies. Histologically, vacuolation was widespread and the nuclei were greatly reduced in size.

Involution of the corpus albicans occurs more rapidly in animals that have mated at postpartum estrus. In lactating, pregnant females with small embryos, only traces are left of the old corpora. If embryos become visible in approximately seven days, the corpora albicantia must regress in a week or less.

Figure 1 shows the seasonal distribution of corpora lutea in 82 visibly pregnant animals. The counts were made with a binocular dissecting microscope and the doubtful counts were then verified through serial sectioning. The most striking thing shown by the graph is that some of the mice had extraordinarily large numbers of corpora lutea. The largest number observed was 29, and 32 animals had 10 or more corpora. In many ovaries with high corpora lutea counts, the corpora are arranged in a helical pattern (Pl. I, D).

The large number of corpora lutea in a pair of ovaries are all of the same age; there is no possibility that they represent an overlap of two generations of corpora lutea. Following parturition, the corpora albicantia quickly regress and are histologically and grossly distinct from a functioning corpus luteum within three days. There is no discernible pattern to the large counts. They are scattered among primiparous and multiparous females. Their number bears no relationship to the crown-rump measurements of the embryos. The largest counts, as shown by Figure 1, are restricted to the height of the main breeding season.

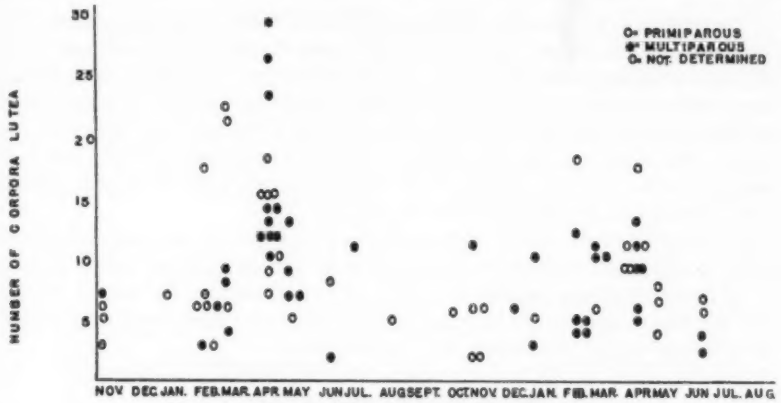


FIG. 1.—Seasonal distribution of corpora lutea.

Histological observations reveal the presence of accessory corpora lutea in *Microtus* which could in part account for the large counts. The fully formed accessory corpora lutea may be indistinguishable from the corpora lutea of pregnancy except for the retention of the ovum or the remains of the zona pellucida. They can be considerably smaller than the primary corpora lutea or of the same size. The difficulty in detecting them is that they form within a very short time, probably within three to four days after ovulation.

The method of formation of accessory corpora lutea in *Microtus* is not clear. Thecal hypertrophy of atretic follicles is observed only in ovaries that contain newly formed corpora lutea. As shown in Plate I, C, the thecal cells of the atretic follicle are very similar to the thecal component of the adjacent corpus luteum. Later postovulatory ovaries show an even more pronounced thecal hypertrophy with an inward migration of thecal cells into the antrum of atretic follicles. Older post-ovulatory ovaries fail to show the fate of the thecal cells of atretic follicles; there is a gap in the slide collection at this point.

Mossman and Judas (1949) found in the porcupine that in follicular atresia the theca cells differentiate into interstitial gland cells while the granulosa cells are transformed into lutein cells. In the water shrew, *Neomys*, both thecal and granulosa components contribute to the accessory corpora lutea (Price, 1953). There is obviously considerable species variation in the method of formation of accessory corpora lutea.

STERILE CYCLE

A number of female *Microtus californicus* undergo a sterile cycle at puberty. This is indicated by the presence of corpora albicantia in combination with the absence of placental scars and any trace of mammary gland development. In most instances these sterile cycles occur in females weighing under 30 grams. Sterile cycles have been shown previously in *Clethrionomys* (Brambell and Rowlands, 1936), *Microtus agrestis* (Brambell and Hall, 1939), and *Peromyscus maniculatus* and *P. boylei* (Jameson, 1953).

The ovaries of prepubertal *Microtus californicus* differ in several respects from the adult gonads. Polyovular follicles have been found in the ovaries of young *Microtus* weighing under 20 grams. In most cases the ova show obvious signs of degeneration or may already show only the vestiges of the zona pellucida. Most of these atypical follicles were biovular, although a few triovular ones were also noted. The largest polyovular follicles had antra and were medium sized. In contrast to the numbers of polyovular follicles found in the immature ovaries, only one was found in all of the adult animals.

A number of small animals with newly formed corpora lutea had undeveloped oviducts and uteri, which suggests that in most instances the ova fail to implant. All of these conditions suggest that some sort of hormonal unbalance is responsible for these sterile cycles and that they represent a "tuning-up" stage before the pituitary-gonad relationship is well established.

AGE OF REPRODUCTIVE MATURITY

During the first year of the study, 35 grams was the weight at which most wild females reached maturity. This weight is reached by captive animals at the earliest by 41 days of age (Hatfield, 1935). In 1953, most females were judged to be sexually mature at 30 grams, a weight possibly attained in a 29 day old animal. Of interest is the weight of the smallest females that showed reproductive activity. In 1952, the smallest wild female having corpora lutea weighed 17 grams, a weight attained by the 17th day in laboratory animals. In 1953, the weight was still further reduced to 15.1 grams, a weight reached by laboratory reared animals at 14 days of age. A wild female weighing 15.1 grams had sperm in the uterus and two-celled tubal ova. The smallest female caught weighed only 10.0 grams, had an open vagina, and the ovary contained medium sized follicles. This display of sexual precocity on the part of *Microtus* is unequalled among mammals.

Such extremely early reproductive activity in *Microtus californicus* seems to be more the exception than the rule as evidenced by the gap between the weights of these precocious individuals and of the visibly pregnant females. Most immature females have only small, infantile tracts.

The early age of the onset of reproduction of *Microtus californicus* seems to be true of all of the species of *Microtus* that have been studied. Hatfield (1935) had previously reported captive female *Microtus californicus* mating when only 21 days old. Hamilton (1941) found that *M. pennsylvanicus* would mate when only four weeks old, and Bodenheimer (1949) reports that female *Microtus guentheri* reach sexual maturity when 25 days old. I imagine that most of these reported early matings would represent sterile breeding cycles.

DISCUSSION

The female reproductive cycle of *Microtus californicus* is shown in Figure 2. Stages followed by a question mark have not been verified. The reason for

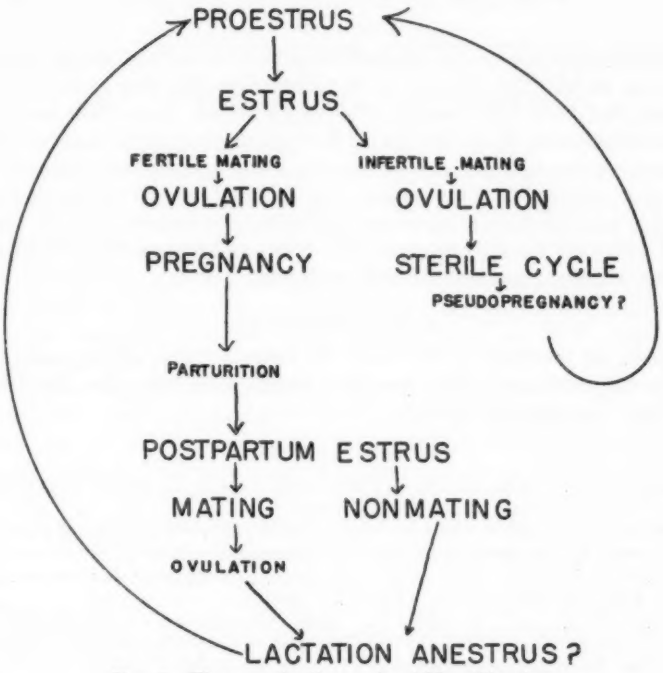


FIG. 2.—The reproductive cycle of *M. californicus*.

hesitating on the designation of lactation anestrus is that lactating females with recently formed corpora lutea have been caught. A female killed three days postpartum was lactating and had large preinseminal follicles. What would have been the condition of the follicles if the female had been killed seven days postpartum? Lactation estrus is a distinct possibility in *Microtus*—at least in the early stages of postpartum cycles.

As for pseudopregnancy, females were not mated with vasectomized males, so that clearcut evidence on this point is not available. Serial sections of several tracts with functional corpora lutea and no visible uterine swellings failed to reveal any traces of blastocysts. The possibility still exists that sections containing the eggs may have been lost. Analogizing with most other small rodents though, it seems quite likely that pseudopregnancy could occur in *Microtus*.

The induced method of ovulation may be of importance in view of the marked population fluctuations of *Microtus*. With relatively high populations, the method of ovulation would be of little significance to any species. Induced ovulation, though, would be of considerable value to a species recovering from a population low, since it would greatly enhance the possibility of a male encountering an estrous female.

SUMMARY

Microtus californicus is an induced ovulator, ovulation occurring within 15 hours post coitum. The follicular cycle closely resembles that of other induced ovulators that have been studied. The corpus lut .um forms from both thecal and granulosa cells. It is functional throughout pregnancy and reached its maximum size towards the end of gestation. Some females had extremely large numbers of corpora lutea; the largest number found was 29. Accessory corpora lutea have been found and may account for these large counts. A number of wild females undergo a sterile cycle at puberty. Some wild females have ovulated and have been impregnated when only two weeks old.

ACKNOWLEDGMENTS

I express my gratitude to Dr. Oliver P. Pearson under whose guidance the problem was conducted. The microphotographs were taken by Mr. Richard Grill of the Carnegie Laboratory.

LITERATURE CITED

BODENHEIMER, F. S. 1949. Problems of vole populations in the Middle East. Research Counsel of Israel, Azriel Printing Works, Jerusalem.

BODENHEIMER, F. S., AND F. SULMAN. 1946. The estrous cycle of *Microtus guentheri* D and A and its ecological implications. Ecology, 27: 255–256.

BRAMBELL, F. W. R., AND K. HALL. 1939. Reproduction of the field vole *Microtus agrestis*. Proc. Zool. Soc. London, series A, 109: 133–138.

BRAMBELL, F. W. R., AND I. W. ROWLANDS. 1936. Reproduction of the bank vole (*Evotomys glareolus*, Schreber). 1. The oestrous cycle of the female. Phil. Trans. Roy. Soc. Lond. B, 226: 71–120.

DAWSON, A. B., AND H. B. FRIEDGOOD. 1940. The time and sequence of preovulatory changes in the cat ovary after mating or mechanical stimulation of the cervix uteri. Anat. Rec., 76: 411–429.

ENDERS, R. K. 1952. Reproduction in the mink (*Mustela vison*). Proc. Amer. Philosoph. Soc., 96: 691–755.

HAMILTON, W. J., JR. 1941. Reproduction of the field mouse *Microtus pennsylvanicus* (Ord). Cornell Univ. Agric. Exp. Stat., Memoir 237.

HANSSON, A. 1947. The physiology of reproduction in mink (*Mustela vison* Schreber) with special reference to delayed implantation. Acta Zoologica, 28: 1–136.

HATFIELD, D. M. 1935. A natural history study of *Microtus californicus*. Jour. Mamm. 16: 261–271.

JAMESON, E. W., JR. 1953. Reproduction in the deer mice (*Peromyscus maniculatus* and *P. boylei*) in the Sierra Nevada, California. Jour. Mamm., 34: 44–58.

MOSSMAN, H. W., AND I. JUDAS. 1949. Accessory corpora lutea, lutein cell origin, and the ovarian cycle in the Canadian porcupine. Amer. Jour. Anat., 85: 1–39.

PRICE, M. 1953. The reproductive cycle of the water shrew, *Neomys fodiens bicolor* Shaw. Proc. Zool. Soc. Lond., 123: 599–621.

ROBINSON, A. 1918. The formation, rupture and closure of ovarian follicles in ferrets and ferret polecat hybrids, and some associated phenomena. Trans. Roy. Soc. Edinburgh, 52: 303–362.

Museum of Vertebrate Zoology, University of California, Berkeley, California. (Present address, Carnegie Institute of Washington, Department of Embryology, Baltimore, Maryland.)
Received August 26, 1955.

NOTES ON REPRODUCTION IN THE STAR-NOSED MOLE

By W. Robert Eadie and W. J. Hamilton, Jr.

Few mammals are more distinctive of North America than *Condylura cristata cristata* (Linnaeus) but its general habits and reproductive history have been little explored; much of the data we have on its mode of life have been gathered by chance. The observations recorded below are fragmentary, but are considered worthy of record since no study of its entire reproductive pattern has been recorded. A few data on the season of reproduction and embryo counts have been recorded by Hamilton (1931). In the past 25 years, additional material has become available that adds to our meager knowledge of the reproductive pattern in this species.

Our data are largely the result of routine trapping in an attempt to secure information on the population dynamics of the small mammals of central and western New York. No real effort has been made to collect these moles, except as specific needs for fresh specimens for glandular studies arose (Eadie, 1948*a*,*b*). The number of fresh specimens inspected by us and our collectors is 145. The reproductive organs of these were grossly examined. Published information on the reproductive cycle of *Condylura* is included to supplement our own observations.

Pairing of the sexes.—It is generally held that the male and female talpid consort only for the purpose of mating, and lead a solitary life at other times. *Condylura* is often found in small colonies and appears to live a gregarious existence with its own kind. Thus we have taken ten individuals in an area of an acre in several weeks of late winter trapping. Three males were taken in a minnow trap at Willseyville, New York on May 25, 1928. The trap was placed in a pool about two feet deep, below the riffles of a large stream.

In several instances a male and female were taken from the same set on successive days in March. On January 26, 1928, a male and female were taken in a minnow trap at Ithaca, New York. The trap was placed in a quiet backwater at a depth of approximately 30 inches. On March 14, 1949, Joseph R. Uzmann recovered two drowned moles in a spring house at Ithaca. The male had greatly enlarged testes and swollen tail and weighed 54 grams. The female, with swollen tail, weighed 47 grams. Her uterine horns were greatly enlarged, as was the turgid vagina. This is presumptive evidence that the species may pair during the winter.

The breeding season.—The breeding season is considered as the period from first matings to the time at which the last litter of the year is weaned. That the female *Condylura* governs this period, as with so many other mammals, is undeniable.

Data on male reproductive condition are presented in Table 1 for 72 moles taken from January to late October. The seasonal growth and regression in testis size (from January through October for adults), and the growth of the

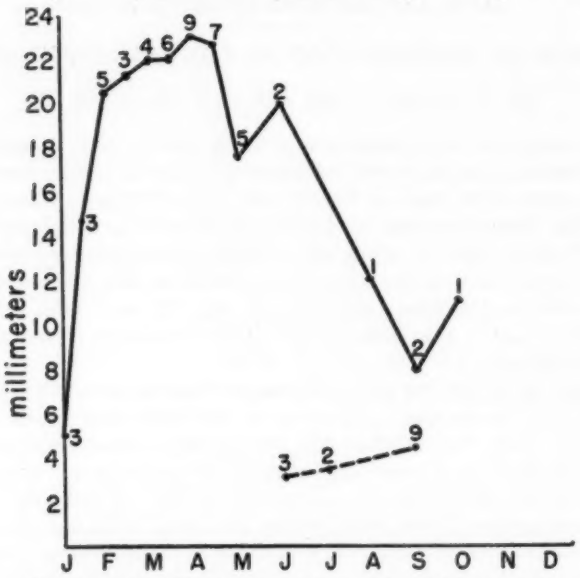


FIG. 1—Length of testes in millimeters for adult *Condylura*. Shown by half-month periods for January, February, March and April. No data for July, November, or December adults. Dashed line shows increase in testes length for juveniles. Numerals at points indicate numbers of specimens in average.

testis in juveniles from June through September are indicated in Figure 1. It is obvious that testis growth begins in January. By late January, individuals may be found with greatly enlarged testes. All males taken in February have large testes although growth appears to continue in some through April, when one individual with relatively enormous testes, measuring 28 mm. long, was recorded. Average testes size begins to drop in May. In June some individuals may be found with testes at maximum size; others may show pronounced regression. No records of testis size in adults is available for July, but one for August shows distinct regression. Testes of adults in August, September, and October are sh-unken, non-turgid, and measure between 8–12 mm. in length.

Testis size does not in itself indicate fertility, but taken with other indicators it is significant. Males with mature spermatozoa were found in late February. The enlargement of the accessory glands of reproduction is probably a good clue to fertility status. In *Condylura* these lag behind the development and growth of the testis. Hamilton (1930) has recorded some data on the growth and regression of these glands. In brief, the prostate gland remains small ("pea-sized") until mid-February when it rapidly enlarges to 12 mm. long or more. At maximum size it may measure 18 mm., but the size from day to day may vary according to the amount of contained secretion, which participates in the formation of a copulatory plug (Eadie, 1948*a*,*b*). There is some indication that regression

in the prostate occurs internally before there is any external indication of regression in size (Eadie, 1948*a*). One specimen showed such internal regression as early as June 1.

The first record of a female with distinguishable macroscopic embryos was on March 16 (Table 2). The April 14 lactating female from southcentral Pennsylvania (Gifford and Whitebread, 1951) implies mating at an earlier date than that recorded above. The latest record of embryos (8 mm.) is recorded from southeastern Pennsylvania on July 23 (Roslund, 1951). Presumably the nursing period for this mole would extend into early September. The paucity of data on the condition of both male and female reproductive organs is evident for the summer months.

From the limited data available, it appears that young may be born from late March until early August, thus covering a period of more than four months. We interpret the records of sporadic summer pregnancies as only the result of late-breeding females. Repeated estrous cycles would provide opportunity for previously unbred females to have a fruitful late mating, since males with enlarged testes, and presumably fertile, have been taken as late as mid-June. Table 2 shows that, for the Ithaca, New York area, all pregnant females have been taken in March (2 specimens), April (14), May (4), and early June (1 specimen). It is obvious that by far the greater number of pregnancies were recorded for the month of April.

Number of young per litter.—The average number of embryos per female for 25 specimens is 5.44 with extremes of 2 and 7. Roslund (1951) reports an individual with 11 placental scars. Records of placental scars in nine specimens (including Roslund's record of 11 placental scars) average 5.4. Of nine nest litters, we have an average of five young (extremes of 3 to 7). The combined 43 records of embryo counts, placental scars and nest young gives an average of 5.25.

Newborn young.—A young mole born to a captive female was characterized as follows. After a few days in 70 per cent alcohol the young weighed 1.5 gm. It measured: total length, 49 mm.; tail, 7; hind foot, 5.7. The head was 14 mm. long. The color was dull white. The eyes were visible as dark swellings beneath the integument, although no evidence of an external ear was present. The fingers of the forelimb were separated, the claws being barely visible on the terminal phalanges. The only evidence of hair was the six short mysticial vibrissae arising from prominent papillae. The conspicuous nasal processes, closely appressed against the snout and lips, were not free. Ayers (1885) stated that at birth the nose of *Condylura* lacked all the distinctive appearance of the adult and looks much more like *Talpa*. Actually these processes may be observed clearly in 16 mm. crown-rump embryos or smaller (Eadie, 1949).

Development and growth of young.—Hamilton (1931) summarizes and gives data on the nestling young. John New collected a litter of six nestling young from a manure pile (Table 2) that were about one-third the weight of adults on May 10, 1952. These young moles were completely covered with fine, black, closely appressed, short hair. As Hamilton (*loc. cit.*) has indicated, these young

TABLE 1.—*Reproductive condition and weights of male Condylura*

Locality	Date	Remarks
N.Y., Ithaca	1/2/28	Testes 3.5 x 1.5 mm.
N.Y., Ithaca	1/15/28	Testes 3.5 x 1.5 mm.
N.Y., Liberty	1/15/52	Testes 8 x 5 mm. John New, coll.
N.Y., Ithaca	1/18/28	Testes 9 x 4 mm.
N.Y., Ithaca	1/29/27	58 gm., testes mod. enl., tail diam. 9 mm.
N.Y., Ithaca	1/29/28	Testes 20 x 8.5 mm.
N.Y., Ithaca	1/30/28	48 gm., testes 15 x 8 mm., tail swollen
N.Y., Ithaca	2/8/28	55 gm., testes 23 x 12 mm., tail greatly swollen
N.Y., Ithaca	2/8/28	62 gm., testes 24 x 12.5 mm., tail greatly swollen
N.Y., Ithaca	2/10/28	55 gm., testes 18 x 8 mm., tail greatly swollen
N.Y., Ithaca	2/10/28	58 gm., testes 19 x 9 mm., tail greatly swollen
N.Y., Ithaca	2/10/28	54 gm., testes 19 x 8 mm., tail greatly swollen
N.Y., Ithaca	2/25/28	Testes 22 x 10 mm., tail swollen
N.Y., Ithaca	2/26/28	Testes 22 x 10 mm.
N.Y., Ithaca	3/3/28	Testes 20 x 9 mm.
N.Y., Ithaca	3/9/48	63 gm., testes 22 x 14 mm., tail not swollen
N.Y., Ithaca	3/10/28	Testes 20 x 9 mm.
N.Y., Ithaca	3/11/28	Testes 25 x 12 mm.
N.Y., Ithaca	3/14/49	54 gm., testes greatly enlarged, tail swollen
N.Y., Ithaca	3/16/28	Testes 25 x 13 mm.
N.Y., Ithaca	3/16/26	51 gm., testes 22 x 10 mm., tail diam. 9 mm.
N.Y., Ithaca	3/20/28	Testes 22 x 10 mm.
N.Y., Ithaca	3/22/28	Testes greatly enlarged, tail swollen
N.Y., Ithaca	3/25/48	56 gm., testes 24 x 15 mm., tail not swollen
N.Y., Ithaca	3/26/38	55 gm., testes greatly enlarged, tail moderately swollen
N.Y., Ithaca	3/26/48	49 gm., testes 18 x 10 mm., tail swollen
N.Y., Ithaca	3/27/48	53 gm., testes 22 x 14 mm., tail swollen
N.Y., Ithaca	4/1/28	Testes 22 x 12 mm.
N.Y., Ithaca	4/1/48	57 gm., testes 25 x 15 mm., tail flabby
N.Y., Ithaca	4/1/48	56 gm., testes 24 x 14 mm., tail flabby
N.Y., Ithaca	4/1/48	49 gm., testes 22 x 13 mm., tail flabby
N.Y., Ithaca	4/2/48	57 gm., testes 22 x 14 mm., tail flabby
N.Y., Ithaca	4/4/48	55 gm., testes 19 x 12 mm., tail flabby
N.Y., Ithaca	4/4/51	65 gm., testes enlarged, 27 mm.
N.Y., Ithaca	4/4/51	65 gm., testes enlarged, 27 mm. John New, coll.
N.Y., Ithaca	4/7/48	56.5 gm., testes 24 x 14 mm., tail not swollen
N.Y., Ithaca	4/11/53	Testes 28 x 15 mm.
N.Y., Ithaca	4/14/53	58 gm., testes greatly enlarged
N.Y., Ithaca	4/16/28	Testes 25 x 12 mm.
N.Y., Ithaca	4/16/28	Testes 24 x 12 mm.
N.Y., Ithaca	4/16/53	Testes 21 x 11 mm.
N.Y., Ithaca	4/17/48	62 gm., testes 22 x 12 mm., tail not swollen
N.Y., Ithaca	4/18/28	Testes 24 x 12 mm.
N.Y., Ithaca	4/20/48	57 gm., testes 21 x 12 mm., tail not swollen
N.Y., Ithaca	4/21/53	Testes 22 x 12 mm.
N.Y., Ithaca	4/22/53	59 gm., testes greatly enlarged, tail not swollen. W. J. Hamilton III, coll.
N.Y., Ithaca	5/4/48	59 gm., testes 22 x 13 mm.
N.Y., Ithaca	5/4/48	50 gm., testes 18 x 11 mm.

TABLE 1.—*Continued*

Locality	Date	Remarks
N.Y., Willseyville	5/25/28	68 gm., testes 18 x 10 mm., tail swollen
N.Y., Willseyville	5/25/28	57 gm., testes 22 x 12 mm., tail swollen
N.Y., Willseyville	5/25/28	55 gm., testes 8 x 4 mm., tail swollen
N.Y., Ithaca	6/3/28	Testes 4 x 5 x 2 mm., juvenile
N.Y., Jefferson Co.	6/14/53	46 gm., testes 2 x 1 mm., juvenile
N.Y., Jefferson Co.	6/15/53	48 gm., testes 15 x 8 mm. W. E. Werner, Jr., coll.
N.Y., Ithaca	6/19/52	60.9 gm., testes enlarged, 25 x 12 mm.
N.Y., Jefferson Co.	6/19/53	43.5 gm., testes 3 x 2 mm., juvenile
N.Y., Jefferson Co.	7/3/53	43.5 gm., testes 3 x 2 mm., juvenile
N.Y., Jefferson Co.	7/11/53	49.5 gm., testes 4 x 2 mm., juvenile
N.H., Durham	8/21/35	Adult, testes 12 x 8 mm., non-breeding
N.Y., Ithaca	9/4/52	46 gm., testes 5 x 3 mm., juvenile
N.Y., Ithaca	9/5/54	66 gm., testes 8 x 5 mm.
N.Y., Ithaca	9/6/52	46.3 gm., testes 4 x 2 mm., juvenile
N.Y., Ithaca	9/9/53	43 gm., testes 5 x 3 mm., juvenile
N.Y., Ithaca	9/14/53	54 gm., testes 4 x 3 mm., juvenile
N.Y., Skaneateles	9/15/49	44 gm., testes 5 x 3 mm., juvenile, tail slender
N.Y., Ithaca	9/15/53	50 gm., testes 3 x 2 mm., juvenile
N.Y., Ithaca	9/16/53	51 gm., testes 4 x 3 mm., juvenile
N.Y., Ithaca	9/20/53	50 gm., testes 5 x 3 mm., juvenile
N.Y., Ithaca	9/26/54	Testes 8 x 4 mm., adult
N.Y., Ithaca	9/30/52	Testes 5 x 3 mm., juvenile
N.Y., Liberty	10/31/52	Testes 11 x 5 mm., John New, coll.

grow rapidly. William J. Hamilton, III collected a litter of five nestling young weighing 31–33 gm. on May 23, 1952. These young were well-furred and able to move about actively. Since at least one immature mole has been collected (by W. E. Werner, Jr.), apparently weaned and living an independent life at a weight of 32.5 gm., it would seem that the young may leave the nest at about this size. Independent, immature moles have been taken in our collections in late May that averaged 41.5 gm. (2); in June, ave. 43.2 gm. (7); in July, ave. 43.5 gm. (2); in August, 48.5 gm. (1); and in September, ave. 47.8 gm. (13). These late summer and early fall weights of young *Condylura* may approximate or exceed those of some adults at this season, so that weight is not a good criterion for use in separating the two age groups. We have found that the cusps of the teeth of juvenile moles in late summer and early fall show little or no wear, while distinct wear is always shown on at least some of the tooth cusps of adults. This appears to be a useful criterion for separating adults and young in the year of birth. Our material was not extensive enough to attempt to establish further age groups on the basis of tooth wear.

The slight degree of wear found on the teeth of some breeding females in the spring indicates that females breed in their first year of life. This is supported by the complete absence of non-breeding females in the spring of the year. Non-breeding males were not recorded in the spring.

Tail enlargement.—The peculiar enlargement of the tail in *Condylura* has been noted often and speculations on its significance made. Hamilton (1931) did not

TABLE 2.—*Data on reproduction for adult female Condylura*

Locality	Date	No. embryos or young	Authority	Remarks
N.Y., Ithaca	3/16/28	6 emb.	Hamilton, '31	Uterine swelling, 4 mm.; emb., 1 mm., 3R, 3L
N.Y., Ithaca	3/29/28	6 emb.	Hamilton, '31	4 mm. crown-rump
N.Y., Ithaca	4/1/48	6 emb.	Present study	Uterine swellings, 3 mm. Tail turgid, swollen
N.Y., Ithaca	4/4/10	5 emb.	Simpson, '23	13 mm. crown-rump
N.Y., Ithaca	4/4/48	6 emb.	Present study	Uterine swelling, 4 mm. Tail normal
N.Y., Ithaca	4/7/48	—	Present study	Uterus swollen. Tail normal
N.Y., Ithaca	4/7/48	6 emb.	Present study	Uterine swellings, 3 mm. Tail normal
N.Y., Ithaca	4/7/28	7 emb.	Hamilton, '31	4–6 mm. crown-rump
N.Y., Ithaca	4/8/53	5 emb.	Present study	Uterine swellings, 1 mm.
N.Y., Ithaca	4/9/53	—	Present study	Early pregnancy
N.Y., Ithaca	4/10/48	7 yg.	Present study	About 2 weeks old
S.Central Pa.	4/14/49	—	Gifford and Whitebread, '51	Lactating
N.Y., Ithaca	4/16/28	6 emb.	Hamilton, '31	Early, small uterine swellings
N.Y., Ithaca	4/16/54	—	Present study	No emb., uterus enlarged
N.Y., Ithaca	4/16/54	—	Present study	No emb., uterus enlarged
N.Y., Ithaca	4/18/28	—	Hamilton, '31	Recent partus
N.Y., Ithaca	4/19/48	7 emb.	Present study	Uterine swellings, 4 mm. Tail normal
N.Y., Ithaca	4/19/48	7 emb.	Present study	Uterine swelling, 7 mm.
N.Central Pa.	4/20/49	5 emb.	Roslund, '51	10 mm. long
N.Y., Ithaca	4/20/52	4 emb.	Present study	25 mm. crown-rump
N.Y., Ithaca	4/20/52	4 emb.	W. J. Hamilton III, coll.	27 mm. crown-rump
N.Y., Ithaca	4/20/52	—	W. J. Hamilton III, coll.	Recent partus, 5 placental scars
N.Y., Ithaca	4/20/52	—	Present study	Recent partus, 5 placental scars
N.Y., Ithaca	4/21/48	3 emb.	Present study	20 mm. crown-rump
N.Y., Ithaca	4/22/28	6 emb.	Hamilton, '31	2 mm. crown-rump
Newton Center, Mass.	4/25/27	3 yg.	Kennard, '29	Nest yg.; ave. t.l. 80, t.20 mm., hairless
N.Y., Ithaca	5/3/48	—	Present study	Nursing
S.Central Pa.	5/3/49	5 emb.	Gifford and Whitebread, '51	24 mm. long
S.Central Pa.	5/6/49	4 emb.	Gifford and Whitebread	1 mm. long
N.Y., Liberty	5/10/52	6 yg.	John New, coll.	Nest yg., ave. 17 gm., t.l. 117, t. 39, h.f. 22 mm.
N.Y., Ithaca	5/11/17	4 yg.	Simpson, '23	Nest yg.; ave. t.l. 92.5, t. 28, h.f. 18.5 mm.
N.Y., Ithaca	5/15/28	7 emb.	Present study	2 mm. crown-rump
S.Central Pa.	5/12/49	4 emb.	Gifford and Whitebread	18 mm. long

TABLE 2.—*Continued*

Locality	Date	No. embryos or young	Authority	Remarks
N.Y., Ithaca	5/17/28	7 emb.	Hamilton, '31	1 mm. crown-rump
N.Y., Ithaca	5/18/28	6 emb.	Hamilton, '31	3 mm. crown-rump
N.Y., Ithaca	5/19/27	6 yg.	Present study	One of 6 nest yg., 25 gm.
District of Columbia	5/22/1898	5 yg.	Jackson, '15	About ½ grown
Nova Scotia	5/22/1890	4 yg.	Bishop, '02	Nest yg., fur beginning to show
District of Columbia	5/23/18	5 yg.	Simpson, '23	Nest yg.; ave. t.l. 86, t. 28, h.f. 19 mm.
N.Y., Ithaca	5/23/52	5 yg.	W. J. Hamilton III, coll.	31–33 gm., almost weaned
N.Central Pa.	5/26/49	—	Roslund, '51	11 plac. scars, uniform
N.Central Pa.	5/31/50	—	Gifford and Whitebread, '51	Lactating
N.Y., Ithaca	6/10/06	—	Hamilton, '31	Female with embryos
N.Y., Jefferson Co.	6/15/53	—	W. E. Werner, Jr., coll.	4 placental scars
N.Y., Jefferson Co.	6/18/53	—	W. E. Werner, Jr., coll.	Non-gravid
N.Y., Ithaca	6/19/52	—	Kile Barbehenn, coll.	5 placental scars, not lactating
N.Y., Jefferson Co.	6/19/53	—	W. E. Werner, Jr., coll.	5 placental scars
N.Y., Jefferson Co.	6/25/53	—	W. E. Werner, Jr., coll.	Non-gravid
N.Y., Jefferson Co.	7/3/53	—	W. E. Werner, Jr., coll.	4 placental scars
Ont., Mazinaw Lake	7/5/49	2 emb.	Christian, '51	Extremely small embryos
Northeastern Pa.	7/14/50	5 emb.	Grim and Whitebread, '52	Ave. 4 mm. long
N.Y., Jefferson Co.	7/19/53	—	W. E. Werner, Jr., coll.	Non-gravid
Southwestern Pa.	7/23/48	3 emb.	Grim and Roberts, '50	Ave. 8 mm. long
N.Y., Jefferson Co.	7/23/53	—	W. E. Werner, Jr., coll.	Non-gravid
N.Y., Jefferson Co.	7/27/53	—	W. E. Werner, Jr., coll.	Non-gravid
N.Y., Jefferson Co.	7/30/53	—	W. E. Werner, Jr., coll.	Non-gravid
N.Y., Ithaca	8/4/48	—	Present study	27 gm. young. Recently weaned?
N.Y., Ithaca	8/12/52	—	Kile Barbehenn, coll.	6 placental scars, not lactating
N.Y., Ithaca	9/9/53	—	Present study	4 placental scars

feel that, on the basis of evidence then available, the tail acted as a reservoir for stored energy. Examination of Table 1, in regard to the condition of the tail in breeding males, does not provide a clear solution to this problem, but it does suggest that tails swollen with fatty tissue may act as a temporary reservoir for energy useful in the breeding season. It may be noted that the great majority of males collected just before and during the height of the breeding season had swollen tails. Presumably, most of the mating takes place in late March and in April (Table 2). It may be significant that many males were collected in April with flabby or with normal-sized tails.

The three males collected on May 25 with swollen tails may indicate that reserves once used may be restored, or that these are late-breeding males.

Summary and conclusions.—Notes on reproduction in *Condylura cristata cristata*, collected over a period of 25 years are presented. Evidence points toward a single litter a year for this mole. Testes and accessory glands may reach breeding condition by mid-February in central New York. The first signs of a return to the resting stage are seen in late May or early June although males in possible breeding condition were found as late as mid-June. The reproductive organs of all adult males taken after July showed marked regression.

The earliest record of macroscopic embryos was March 16 (locally) and the latest, July 23 (southeastern Pennsylvania). Except for two non-local records, all pregnant females have been taken in March, April, May or early June, with by far the largest number in April.

The average number of embryos was 5.44; average number of placental scars, 5.4; and average number of nest young, 5.

A newborn young is described. The young moles grow rapidly and are two-thirds grown when they leave the nest (about 33 grams or more). By August and September, immature moles may approximate or, in some cases, exceed some adults in weight. Juveniles may be separated from adult specimens by the absence of tooth wear.

Condylura males and females breed in their first year of life.

Some evidence is given that the enlarged tail of *Condylura* represents stored food for the breeding season.

LITERATURE CITED

Ayers, H. 1885. On the structure and development of the nasal rays in *Condylura cristata*. Biol. Centralb., 4: 358–359.

Bishop, W. L. 1902. A nest of the star-nosed mole. Trans. Nova Scotia Inst. Sci., 10: 349.

Christian, J. J. 1951. The mammals of the Mazinaw Lake region of Ontario; their reproduction and population dynamics. Annals Carnegie Mus., 31 (Art. 18): 339–386.

Eadie, W. R. 1942*a*. The male accessory reproductive glands of *Condylura* with notes on a unique prostatic secretion. Anat. Rec., 101: 59–80.

———. 1948*b*. Corpora amylacea in the prostatic secretion and experiments on the formation of a copulatory plug in some insectivores. Anat. Rec., 102: 259–272.

———. 1949. Star-nosed mole (Photo.). Turtox News, 27: 127.

Grim, W. C. and H. A. Roberts. 1950. Mammal survey of southwestern Pennsylvania. Pennsylvania Game Comm., Harrisburg. 99 p.

Grim, W. C. and R. Whitebread. 1952. Mammal survey of northeastern Pennsylvania. Pennsylvania Game Comm., Harrisburg. 82 p.

HAMILTON, W. J., JR. 1930. The biology of the star-nosed mole, *Condylura cristata* Linnaeus. Cornell Univ. Ph.D. thesis.

———. 1931. Habits of the star-nosed mole, *Condylura cristata*. Jour. Mamm., 12: 345–355.

GIFFORD, C. L. AND R. WHITEBREAD. 1951. Mammal survey of south central Pennsylvania. Pennsylvania Game Comm., Harrisburg. 75 p.

JACKSON, H. H. T. 1915. Review of the American moles. N. Amer. Fauna, No. 38. 100 p.

KENNARD, F. H. 1929. A star-nosed mole's nest at Newton Centre, Massachusetts. Jour. Mamm., 10: 77–78.

ROSLUND, H. R. 1951. Mammal survey of northcentral Pennsylvania. Pennsylvania Game Comm., Harrisburg. 55 p.

SIMPSON, E. S. 1923. The nest and young of the star-nosed mole. Jour. Mamm., 4: 167–170.

Department of Conservation, Cornell University, Ithaca, N. Y. Received June 27, 1955.

FURTHER NOTES ON ANTLERS IN FEMALE DEER OF THE GENUS *ODOCOILEUS*

BY GEORGE B. WISLOCKI

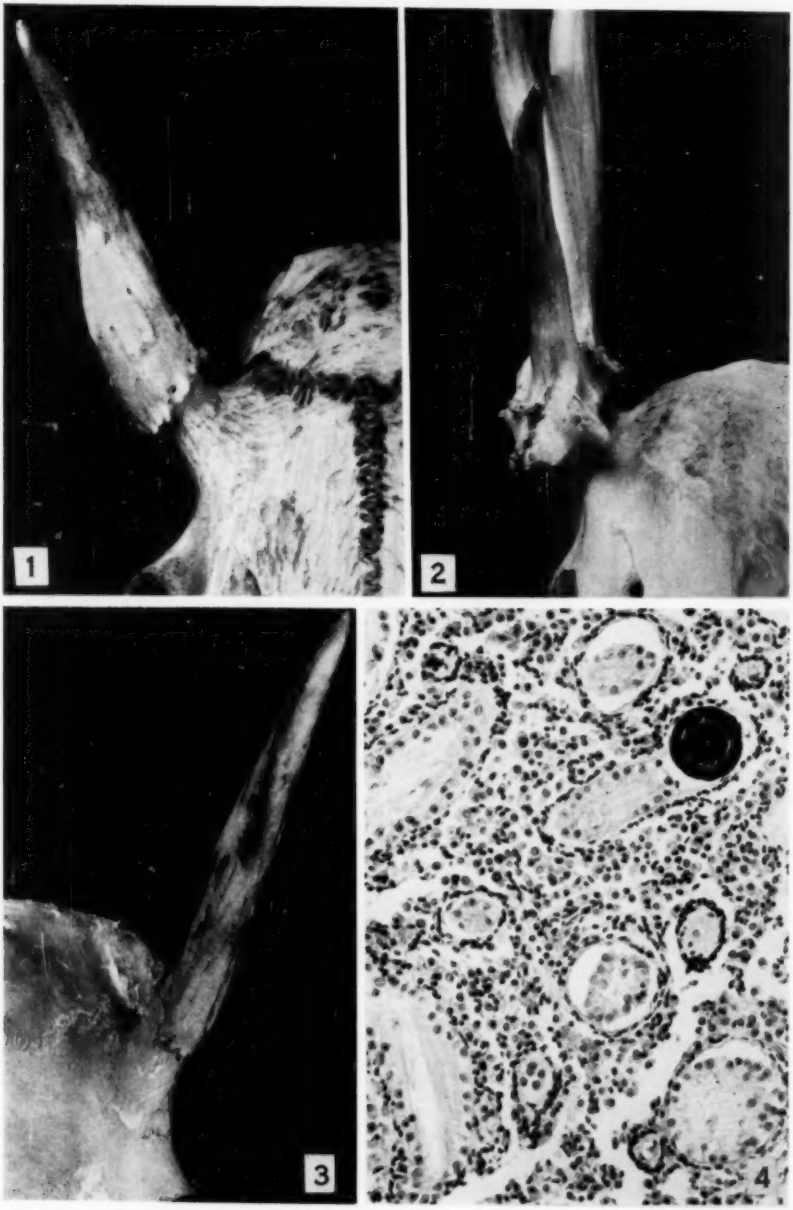
With the exception of reindeer, female deer do not possess antlers. However, antlers occur sporadically in other genera, especially in *Capreolus* and *Odocoileus*. In the former, the size and condition of the generally abnormal antlers has been correlated to some degree with the condition of the reproductive tract, the largest antlers occurring in does that are either true hermaphrodites or pseudohermaphrodites and are infertile. Small deformed antlers in velvet are usually found in does that possess ovaries and often reveal signs of a previous pregnancy. The present investigator described the reproductive tracts of three antlered does of the genus *Odocoileus* (Wislocki, 1954). In two animals the ovaries were completely normal and in the third, atrophic, but in all three there was unmistakable evidence of their having previously been fertile and having borne young. In each case the antlers were very small, abnormal, and in velvet.

As a result of the publication of those observations, the writer has received communications from several conservation officers in the United States, supplying him with specimens and accounts of other antlered does. The material and notes received seem sufficiently interesting to warrant a further brief communication on the subject of antlered does. This study was aided by a grant of the Eugene Higgins Trust of Harvard University.

The data include reports of four deer, three of which are similar to the antlered does recently described by Wislocki. The fourth, however, is particularly interesting because it is either a true hermaphrodite or pseudohermaphrodite and in either event, the first of its kind to be noted in the genus *Odocoileus*.

The four cases are presented below:

(1) A whitetail doe collected in Massachusetts on December 6, 1954, estimated to be five and a half years old, with a velvet-covered spike antler on the right side, measuring three and a half inches in length (Pl. I, 1). The animal was lactating and accompanied by two fawns. The ovaries were not examined. (Courtesy


1
2
3
4

of Mr. Charles A. Stiles and James J. McDonough, Department of Conservation, Massachusetts.)

(2) A mature mule deer doe killed in October, in Idaho, bearing two fairly symmetrical, velvet-covered spikes which were two and three quarters and four and a half inches in length. The animal was lactating and accompanied by a fawn. The normal ovaries, examined by Cheatum's method, contained a regressing corpus luteum. (Courtesy of Dr. Paul D. Dalke and Mr. Burt McConnell, Assistant Game Biologist, Idaho Cooperative Wild Life Research Unit).

(3) A whitetail doe killed on Beaver Island, Michigan on November 16, 1951. judged to be two and a half years old and bearing two small symmetrical spikes in velvet, each about five inches long. Milk was not present in the mammary glands and the nipples were not enlarged. The ovaries were not examined. (Courtesy of Mr. Lawrence A. Ryel, Michigan Department of Conservation.)

(4) A whitetail deer, shot in Ste. Genevieve County, Missouri on November 28, 1950, judged to be two and a half years old. The antlers were hard and polished. The right antler bore one point and a basal snag, and the main beam, with part of the tip broken off, measured eight and a half inches in length. The left antler which bore two points and a basal snag was twelve and three quarter inches in length. Although not so well developed as the antlers of most two and a half year old bucks, they appeared in no way atypical.

This animal possessed female external genitalia including a vagina of normal size. The latter ended blindly in a tough, cervix-like tissue, but no uterus could be identified. Instead, a slender tubular structure arose on either side of the cervix, one of which, on the left, could be traced for five inches to a small mass in the pelvic wall, embedded subperitoneally in fat and connective tissue. The termination of the other tube could not be ascertained, because it had probably been removed in cleaning the deer.

The small pelvic mass on the left side was sent to Dr. H. W. Mossman of the University of Wisconsin for examination. Upon sectioning it histologically, he identified it as a cryptorchid testis. Through the courtesy of Mr. Allen Brohn, Biologist, Mammal Unit of the Missouri Conservation Commission, who brought the animal to my attention, I have also received a histological section of the testis, a microphotograph of which is shown in Plate I. It is observed that the atrophic seminiferous tubules are lined solely by Sertoli cells and are widely separated by loose masses of rounded interstitial cells. The conspicuous interstitial tissue contains numerous eosinophiles and lymphocytes. An unusual fea-

---

PLATE I

1, 2 and 3. The small abnormal antlers of three whitetail does, from which the velvet was removed in order to examine the configuration of the base of the antlers. Notice that number 3 has no corona whatsoever, whereas in 1 and 2, the abnormal antler base variously overhangs the pedicle. For further discussion see the text.

4. Histological section of a cryptorchid gonad from an hermaphrodite whitetail deer. Observe that the gonad is testicular in character, consisting of seminiferous tubules lined solely by Sertoli cells and widely separated by interstitial cells. A dark-stained concretion is present in the lumen of one of the tubules. × 175.

ture is the presence of a number of small basophilic bodies resembling concretions, one of which is visible in Figure 4. As Mossman remarked in his unpublished report to Mr. Brohn, these seem to be both inside and outside the seminiferous tubules, although those that are outside may have arisen by degeneration of the wall of the seminiferous tubule around them.

DISCUSSION

The conclusion reached in a previous paper (Wislocki, 1954) that antlered does of the genus *Odocoileus* are usually females that are sexually normal and fertile and have given birth to young is illustrated by three further examples. In such animals the antlers are small and irregular, and the velvet is retained. The possible endocrine explanation of these antlered does is discussed in the previous paper (Wislocki, 1954).

A fourth case, presented here, is quite unusual, in that the deer possessed female external genitalia combined with a small cryptorchid testicle. This animal must have been an hermaphrodite, although, whether it was a true lateral hermaphrodite or a pseudohermaphrodite (as illustrated diagramatically for *Capreolus* in the author's previous paper) cannot be ascertained because one gonad had been discarded in cleaning the deer. This is the first record of an hermaphrodite in *Odocoileus*, verified by histological examination of the gonadal tissue, and the first microphotograph of a cryptorchid testis of an hermaphrodite in any species of deer. As is generally true of hermaphrodites in *Capreolus* (Rörig, 1899, 1907), the antlers in this specimen of *Odocoileus* are also well-developed, devoid of velvet and polished, a condition probably attributable to relatively strong stimulation by testosterone.

Rörig (*loc. cit.*) claimed that in hermaphrodite roe deer the burr or corona is always present on their well-developed antlers that shed the velvet, whereas the corona is generally absent in does that possess poorly developed antlers that remain permanently in velvet. The present investigator has had an opportunity to examine the antlers of three whitetail deer of the latter type. The small, single antlers present in these are illustrated in Plate I, as they appeared after the velvet had been removed. It will be noted that none of them possesses a typical corona, although, in the specimens shown in Numbers 1 and 2, the antler bases are observed to be very definitely larger than the pedicles that they surmount. In Number 3, however, the antler base passes over imperceptibly into the pedicle without any thickening. Number 1 illustrates the first case of the present series, while Numbers 2 and 3 represent the antlers of the first two does of the previous series (Wislocki, 1954). With regard, also, to the antlers of the second animal of the present series, which the writer has not actually examined, Mr. McConnell writes "I am quite certain the antlers lacked a corona or enlargement at their attachment to the pedicels. As I recall, the union was quite smooth." Since the above was written, another head of a seemingly otherwise normal antlered doe was given to me by Mr. James McDonough. A small, abnormal, two-pronged antler in velvet was present on the left side. The antler base was quite irregular and very much larger than the pedicle to which it was attached,

resembling the condition of the antlered doe shown in Figure 2. These various observations indicate that the bases of the small, deformed antlers that develop sporadically in otherwise normal does of the genus *Odocoileus* are about equally divided into those that do and those that do not possess a burr. Thus the ratio differs somewhat from that expressed by Rörig for *Capreolus*.

In several does in which antlers were induced experimentally by administering testosterone propionate, Waldo and Wislocki (1951) observed no corona or swelling of the antler base on the small, velvet-covered, permanent antlers. In contrast to these, in the hermaphrodite whitetail deer of the present series, the antlers were hard and polished, and normal in every respect, an observation that corroborates Rörig's conclusion that the well-developed antlers of hermaphrodite deer possess a normal corona. In this connection, it is interesting to recall that, in normal male deer, Waldo and Wislocki (1951) advanced reasons for believing that the upward thrust of growing skin upon the corona constitutes a factor contributing to the shedding of the antlers. If this be the case, then the better developed the corona is, the greater likelihood there would be of the antlers being shed and, conversely, the less well-developed the corona is, the less likelihood there would be of shedding taking place.

SUMMARY

Three additional cases of antlered female deer of the genus *Odocoileus* are described. As in three previous instances, these does had small abnormal antlers, possessed normal genital tracts and appeared to be fertile.

A fourth deer of the present series appears to be an hermaphrodite. It possessed polished antlers of normal form, associated with female external genitalia and a vagina but internally with a cryptorchid testis. This appears to be the first case of an hermaphrodite in any species of deer in which the condition has been verified by histological examination of a gonad.

LITERATURE CITED

RÖRIG, A. 1899. Welche Beziehungen bestehen zwischen den Reproduktionsorganen der Cerviden und der Geweihbildung derselben? Arch. f. Entwicklungs mech., 8: 382–425.

———. 1907. Gestaltende Correlationen zwischen abnormer Körperkonstitution der Cerviden und Geweihbildung derselben. Arch. f. Entwicklungs. mech., 23: 1–150.

WISLOCKI, G. B. 1954. Antlers in female deer, with a report of three cases in the genus *Odocoileus*. Jour. Mamm., 35: 487–495.

WALDO, C. M. AND G. B. WISLOCKI. 1951. Observations on the shedding of the antlers of Virginia deer (*Odocoileus virginianus borealis*). Amer. Jour. Anat., 88: 351–396.

Department of Anatomy, Harvard Medical School, Boston, Massachusetts. *Received September 9, 1955.*

BRONCHIAL DIVERTICULA IN *BLARINA BREVICUADA*

By Wesley W. Parke

A cursory examination of the thoracic viscera of the short-tailed shrew, *Blarina brevicauda* (Say), revealed a pair of extrapulmonary bronchial diverticula emerging from the dorsal caudal margin of the right posterior lobe of the lung. These received only passive interest as anomalous developments peculiar to the individual, until their presence in subsequently dissected specimens suggested that they might be a variation characteristic of the species.

Though distal extrapulmonary extensions of the bronchi occur in birds and certain reptiles, where they function as vital or ancillary components of the respiratory system, no homologous structures have been described as a constant anatomical entity in mammalian lungs.

By virtue of size and location, the bronchial diverticula in the shrew were non-functional in any respiratory capacity, and the existence of a more subtle selective factor was suspected to be responsible for their perpetuation in the heredity of the species. Therefore, in addition to a description of the diverticula, this study included an attempt to derive a functional apology for their occurrence from the histological and morphological picture presented by the lung of *Blarina* with regard to comparative evidence.

OCCURRENCE OF DIVERTICULA

The diverticula were found in all of ninety-four short-tailed shrews taken in Tolland Co., Connecticut. However, to ascertain if they were a universal possession of the species, a series geographically indicative of the population was necessary.

The range of *Blarina brevicauda*, inclusive of several subspecies, covers all of eastern United States, extending from southeastern Canada to Florida, and west of the Mississippi as far as Nebraska. Through the courtesy of Dr. W. H. Burt, formalin-preserved specimens representing the following subspecies and locations were obtained from the University of Michigan Museum of Zoology: one *B. brevicauda brevicauda*, Ontario, Wellington Co.; one *B. brevicauda brevicauda*, Maine, Franklin Co.; five *B. brevicauda brevicauda*, New Hampshire; four *B. brevicauda brevicauda*, Ohio, Wayne Co.; one *B. brevicauda carolinensis*, Mississippi; one *B. brevicauda peninsulae*, Florida.

One hundred and six *Blarina* were examined in total, and the diverticula were present in all save the peninsular specimen. Their absence in this individual may have been coincident, and no conclusions can be drawn from a single example. Should the lack prove consistent to the group, it might indicate that the evolution of the subspecies was antecedent to the development of the diverticula in the parent stock.

Concurrently, series of lungs from other mammals were examined to provide comparisons. The study included inspection of the respiratory system in domestic cats, dogs, guinea pigs, laboratory mice, *Peromyscus leucopus*, *Sorex cinereus*, *Cryptotis parva*, *Scalopus aquaticus*, and *Condylura cristata*. Particular

attention was given to other insectivores in deference to the possibility that the diverticula may have been a remnant of a previously established extraneous lobe still evident to some degree in related forms.

No condition resembling the diverticula in *Blarina* was found in any other species. In exclusion of this peculiarity, the general morphology of the lung lobes and the remainder of the bronchial pattern was consistent with other small insectivores and small rodents.

METHODS

The bronchial distribution of *Blarina* and other small mammals was studied by dissection and corrosion casts of Wood's Metal.

Cast preparations were made by securing the trachea to a tapered glass cannula and suspending the entire thoracic viscera from a two-holed rubber stopper placed on an Ehrlenmyer flask. A small quantity of ethyl alcohol, boiled in the bottom of the flask, preheated the tissue eight degrees above the fusion point of the metal (70°C.) and ensured that premature hardening would not occlude the terminal ducts. The condensation vacuum of the alcohol, controlled by admitting air through the second hole in the stopper, drew the molten metal from the cannula directly to the most distal respiratory areas. As further reproduction of the smaller bronchial network and alveolar spaces obscured the bronchial pattern, penetration was halted.

Wood's Metal was preferred to latex or plastic injection masses because its hardness and rapid solidification provided a more accurate impression of superficial irregularities and revealed differences in the resiliency of the bronchi at the same levels suggested in their histology.

Sodium hydroxide was employed as the corrosive agent as it left the bronchial and tracheal cartilages relatively intact, imbedded in their individual depressions on the cast. Acidic maceration failed to show this differential respect for chondrous tissue.

For histologic sections, the organs were suspended on a tracheal cannula as described above, and fixed under intrapulmonary pressure provided by a vertical column of Newcomer's (1953) fluid. Distention of the bronchi was desirable, as erroneous conceptions, especially concerning the nature of the musculature, have been attributed to the use of relaxed material (Macklin, 1929). Individual lobes were imbedded in paraffin, sectioned at seven and fifteen micra, and stained with a modification of the Giemsa blood stain (Gatenby and Beams, 1950).

GROSS DESCRIPTION

The superficial appearance of the lungs of *Blarina* showed the marked asymmetry that was found characteristic of small mammals of similar general morphology. The relative dimensions of the five lobes reflected the pronounced anterior constriction of the thorax as it conformed to the narrowness of the pectoral girdle. This feature, apparently an adaptation to fossorial habits, in conjunction with the sinsitral position of the heart, has restricted the size of

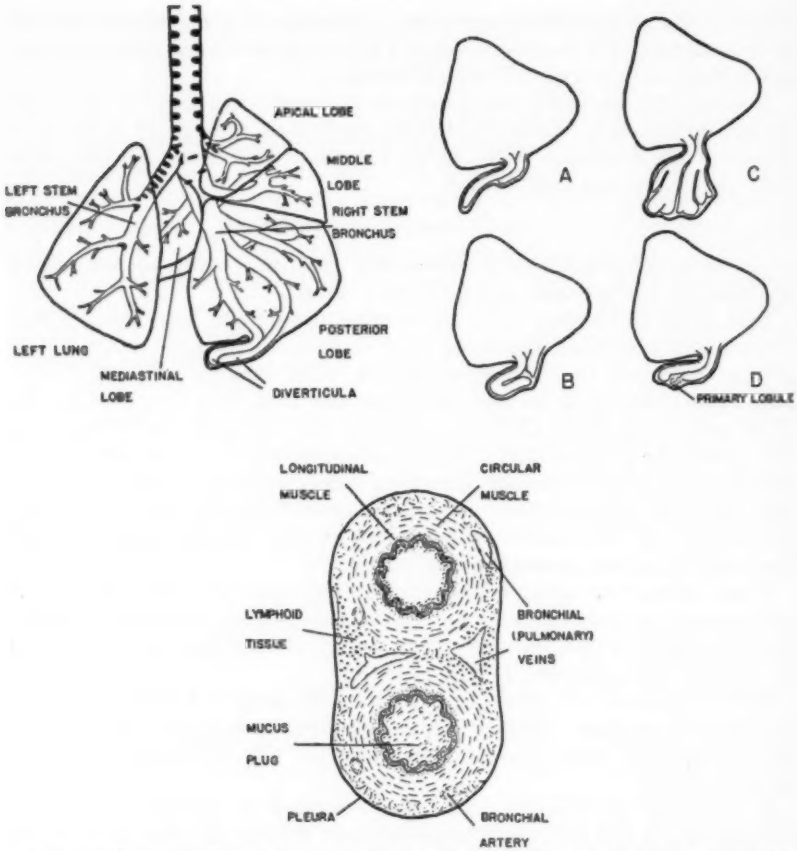


FIG. 1.—TOP LEFT: Dorsal aspect of the lung of *Blarina brevicauda* showing bronchial distribution and diverticula in their typical f m. Composite drawing from corrosion cast and inflated lung.

TOP RIGHT: Variations of the diverticula with the right posterior lobe included to show relative proportions.

BOTTOM: Cross section of the diverticula. A diagrammatic drawing of the typical histology.

the right apical and left segments. In consequence, compensatory development has favored the caudal derivatives of the right stem bronchus.

A single lobe, thin and compressed dorsolaterally, formed the entire left lung. The right lung, in contrast, was composed of four segments; a small apical lobe derived from the trachea, a falciform middle and a prismatic mediastinal lobe derived laterally and ventrally from the proximal stem, and a large posterior lobe.

The right posterior lobe was larger than the left lung. Compensatory emphasis in the development of this component was primarily manifested by a medial expansion permitted through the leftward displacement of the heart and mediastinum. The posterior vena cava retained its conventional relationship to the center of the diaphragm, and though still enclosed in an extension of the mediastinal pleura, it was accommodated in a deep spiral cleft in the median caudal margin of the lobe.

Dissection and cast corrosions revealed a conventional arboration of the bronchi in all segments except the right posterior lobe (Fig. 1). Where in all other mammals, the right stem bronchus forms a single epicentric axis in this segment to which all other bronchi are subordinate, the presence of the diverticula in *Blarina* precluded such an arrangement. The right stem, upon entering the lobe, exserted a large version of a third lateral bronchus and shortly after divided dichotomously into equal terminal tributaries. These branches followed divergent courses for several millimeters and supplied their respective areas with small derivatives. As the right member approached the lateral caudal extremity of the lobe, it turned medially, rejoining its complement at the dorsal caudal margin where the two bronchi emerged from the lung substance as extrapulmonary diverticula.

In their typical form the coadherent diverticula extended three to six millimeters beyond the margin of the lobe and lay in the costophrenic sinus formed by the diaphragmic reflexion of the parietal pleura. The diverticula were encased in a single evagination of the pulmonary pleura, and upon leaving the lung, turned medially and followed the caudal margin toward the mediastinum.

Their morphology in the majority of *Blarina* was as described and illustrated, allowing variations of a few millimeters in length. But atypical forms were noted in about one of every eight specimens and usually involved relative discrepancies in the length of either diverticulum (Fig. 1, A and B). Infrequently, the structures were simply deflected to the right. A few cases showed a tendency to arborate; the extreme result presenting the bizarre form taken from an Ohio specimen (Fig. 1, C).

Found in one individual was an inflated primary lobule pendent from the terminus of the posterior diverticulum (Fig. 1, D).

HISTOLOGY

The bronchi of *Blarina* proved unusual histologically in addition to the gross variations of their distribution. The tracheal pattern of incomplete cartilaginous rings is continued in the proximal stem bronchi of other mammals. In the larger members of the class, these close, totally encircling the bronchus as it enters the lung, and are succeeded by irregular plates that peripherally diminish in size and number leaving the terminal bronchi devoid of chondrous investment.

Intrapulmonary cartilage in shrew-sized mammals was found only adjacent to the hilus, wedged in the acute angles formed by the branching of the larger bronchi, or was lacking. The termination of the ring series at the hilus was easily

detected in the cast corrosions where the pressure produced a spurious increase in bronchial dimensions.

With respect to *Blarina*, the above condition was noted only in the left stem. The right stem bronchus possessed no cartilage except for a few scattered plates near its origin, and the remainder of the stem structurally resembled its distal derivatives. The most salient histologic variation of the right stem was the grossly palpable distal increase in the thickness of its walls. Serial sections revealed that this was due to an exceptionally heavy muscular layer.

Early descriptions have alluded to a similarity between intestinal and bronchial musculature, but Macklin (1929) points out the inaccuracy of this conception. The muscles of the bronchi do not form an imperforate sheath, but an open-meshed pattern of thin anastomosing bundles to which Miller (1947) has applied the term "geodesic network." Even in the guinea pig, which, according to Miller, possesses the heaviest pulmonary musculature of any animal he had observed, the plexiform distribution of the bands was still obvious.

Without exception, the geodesic pattern was apparent in all animals studied in comparison with *Blarina* when the bronchi were fixed under intrapulmonary pressure. In the short-tailed shrew, however, the diverticula and the bronchi in direct continuity displayed a continuous sheath of muscle which exceeded, in relative thickness, that of the intestine. The analogy to the gut was further extended by the presence of two distinct layers; although these were found in the reverse order. An outer circular layer provided the bulk of the bronchial wall, while an inner longitudinal layer, though less conspicuous, ran adjacent to the bronchial epithelium. The integrity of the sheath and the contrasting direction of the layers were best demonstrated in tangential sections of the bronchus and diverticulum.

Connective tissue of the lamina propria separates the bronchial constrictors from the epithelium in larger mammals, and fills the interstices of its rugae. This layer is much reduced in the smallest members of the class, and the longitudinal muscle in *Blarina* appeared to abut directly the basement membrane, mingling with the sparse elastic fibers.

The tissues of the diverticula, including their pleural evagination, were supplied by the bronchial arteries. As in other mammals, these fine vessels were variable in number and origin, arising from the aorta and/or its branches at any point where they approximate the radix or the pulmonary ligament. Entering the hilus, the vessels subdivide to form an arterial plexus around the bronchi. According to Miller (1907) (1947), the bronchial arteries serve all conductory ramifications, excluding the respiratory bronchioles which, like other lung tissue, are supplied by the pulmonary system. The thick pleura of larger mammals (man, pig, ox) is also supplied by the bronchial arteries, but in the small mammals the pleura consists of a single layered mesothelium, served by the pulmonary system.

Within the lung, the bronchial arteries drained by anastomosing with capillaries of the pulmonary vein. In the diverticula, however, the capillaries coalesced

to form discrete bronchial veins that recurrently led to the lung substance and joined the terminal pulmonary veins. These were demonstrated by injecting India ink into the left auricle after blocking the ventricle with paraffin.

The distal bronchial arteries were shown only when the left ventricle was injected under considerable pressure. Their independence of the pulmonary artery was more easily demonstrated when injection of the right ventricle left the bronchi and diverticula blanched, but darkened the remainder of the lung tissue.

In cross-section (Fig. 1), the diverticulum of the median variant bronchus lay anterior to its lateral equivalent as the structures were directed to the left. Between the pleura and the circular muscle was a compact layer that contained the blood vessels and lymphatics. Its primary constituents were lymphoid cells interspersed in connective tissue, resembling atelectatic respiratory areas of the lung. The mucosa of the diverticula, as in the bronchi, was rugose, producing a much folded outline in spite of the intrapulmonary pressure of fixatives. It consisted of a simple ciliated columnar epithelium which contained, in profusion, mucus producing goblet cells.

The crypts formed by the mucosal folds consistently contained mucus, and in many individuals the substance was of sufficient quantity to fill the terminal lumina. This mucus plug included many free monocytes that were suspected to be macrophages endogenous to the peripheral lymphatic tissue whose cells they resembled in morphology and staining qualities.

DISCUSSION

Though the presence of the diverticula in all *Blarina* examined, excepting the peninsular specimen, leaves little doubt that the structures are a "normal" anatomical feature in this animal, their origin is regarded to be similar to that of anomalous diverticulate elements occasionally found in the embryonic and adult lungs of other mammals.

Narath (1892) and D'Hardiviller (1897) noted atypical bronchial vesicles in the embryo rabbit. The latter described these as a transient phenomenon representing the ontogenetic vestiges of a bilateral homologue of the right eparterial component.

Bremer (1932) reported "accessory" tracheal bronchi in the embryos of man, sheep, rabbit, and pig. Because of multiple incidence in some individuals he discounted D'Hardiviller's concept of homology, but reinforced the record of their ephemeral nature. Finding the occurrence of diverticula was disproportionately high in the human embryo (five per cent of examined series) as opposed to the adult, Bremer concluded that many disappear in subsequent development.

Flint (1906), in a detailed work on lung development in the pig, observed that the growth of incipient bronchi may be mechanically suppressed. He also noted that the secondary bronchial anlagen, when first apparent, are arrayed in conformity to the bronchial pattern of the species that anticipates the most eco-

nomic usage of the alloted thoracic space. As this implies that the normal bronchial arboration is genetically determined, many adventitious bronchi may be regarded as mutations.

The fate of mutant bronchi appears to be determined by the extent of development achieved prior to the incurrence of mechanical suppression which, in turn, depends upon their location. The cases reported by Bremer and D'Hardiviller were restricted to the trachea and proximal stem bronchi where the incidence of complete disappearance is likely to be quite high. In the narrow confines of the developing anterior thoracic region such expressions are apt to encounter immediate spatial competition with other viscera. With early suppression, a rudimentary bronchus may be outgrown in the subsequent development of the organ and fail to appear in the adult lung. In the caudolateral regions, however, the continual expansion of the pleural cavity would permit considerable growth of aberrant bronchi, possibly through several orders of subdivision, before spatial embarassment is realized. These anomalies would persist in the definitive form of the lung as cul-de-sacs.

Norris and Tyson (1947) have described such conditions in man where malformed bronchi appear as diverticulate saccular dilations or cysts. The latter they assumed were the result of segmentation.

It is quite plausible that cystic forms exemplify the consequences of inopportune bronchial position when mechanical inhibition is brought to bear in a relatively advanced stage of development. With the late increase in the lung parenchyma, an over-extended or misplaced bronchus may suffer lateral compression at certain points where the characteristic plasticity of the growing lung tube would permit segmentation. The distal portions then continue to differentiate, acquiring the histological identity of bronchi.

Whether diverticulate or cystic, the anatomical consequences of bronchial mutation, unless rather extensive, offer little impairment to lung function *per se*. But, lacking a terminal respiratory area, diverticula can not be purged through coughing and therefore must rely on other mechanisms to prevent their accumulation of mucus and foreign matter. Ciliary action under normal conditions may efficiently keep the bronchi free of excessive amounts of these substances, but in the event of mucogenic irritation, the lung must rely on the cough reflex and bronchial peristalsis.

Though Macklin (1929) has radiologically observed peristaltic action in human bronchi, the efficacy of this mechanism in the absence of pneumatic assistance is questionable. A considerable literature describes intrapulmonary bronchial defects and the doubts concerning their origin, for the majority have been brought to attention because of pathological complicity. The most controversial condition in this respect is bronchiectasis. By definition, this term simply means abnormal dilatation of the bronchus, but it is most often applied to atrophic changes associated with the accumulation of exudate, due to the failure of bronchial expurgation.

Bronchiectasis may be an acquired condition of an anatomically normal lung, but frequently the implication of congenital malformation is obvious

(Ogilvie, 1941). It would appear that such anomalies for which mutation is amenable would selectively be eliminated in the heredity of natural populations because of their predisposition to poor drainage and secondary infection.

A copious accumulation of mucus was also characteristic of the diverticula in *Blarina*. The amount varied with the specimen, and though it often filled the distal half of the extrapulmonary extension, sectioning showed the mucosa was unaffected. Judging by the numerous goblet cells in the epithelium, most of the mucus was believed endogenous to the structures. The basophilic monocytes suspended in the mucus showed irregular cytoplasmic inclusions and were suspected of phagocytizing foreign matter, as a similar function has been shown by free and fixed macrophages in the respiratory areas.

Macrophages can afford little protection against inhaled irritants unless a means of eliminating both the phages and their inclusions is also provided. The variability of the mucus content and its near absence in some cases suggested that the diverticula are capable of periodic expulsion of their contents. The comparative histology of the *Blarina* lung offers considerable evidence in favor of this conjecture, for if such action is produced by the sparse geodesic fibers in other animals, the heavy double-layered musculature in the diverticulate bronchi is more structurally suited to the function. Though actual peristalsis was not observed, the application of acetylcholine to freshly dissected lung elicited a pronounced contraction and constriction of the diverticula.

Peristal[1] [3] could be the major force of bronchial expurgation throughout the entire right stem. Unlike all other mammals, the only chondrous investment in the right stem of *Blarina* was a few small platelets adjacent to the trachea. The left stem, alone, possessed cartilaginous rings that imposed sharp limits upon caliber changes.

Though the diverticula in the shrew may avoid the pathologic predisposition of homologous anomalies in other mammals by the fortunate coincidence of histologic variation, their universal success in the heredity of the species is not explained by benignancy. The possibility of the diverticula being a functional asset to the animal depended on the additional coincidence of its location in respect to the costophrenic sinus and the right stem bronchus. The costophrenic sinus has provided the only space in the pleural cavity where such extrapulmonary exsertion would be tolerated while still preventing its elaboration of a functional lung lobe.

However, as the sinus offers equal opportunities to both the right and left lung, the unilateral incidence of the diverticula may not be purely chance. The posterior segments of either lung in man prove more liable to be the initial foci of pathological processes than the remainder of the organ. But Miller (1913) observed that the right lung is more subject to neoplastic and infective pathology than the left, and the right lower lobe is the most frequently affected portion. The greater defection of this region was attributed to the pneodynamic effects of asymmetrical bronchial distribution. Besides being the smaller of the pair, the left bronchus is more laterally directed, while the right, exposing the largest lumen, remains more in line with the trachea. Larger quantities of

foreign matter, following the more forceful draft and the most direct course, are therefore aspirated into the lower right lung stem. According to Miller, this tendency is enhanced by the action of the trachealis muscle which is inclined to displace the tracheal carina further to the left during inspiration.

It may be generalized that a similar relationship exists in other mammals in direct proportion to regional accessibility. Though unequal bronchial distribution is the prevalent condition in mammals, the degree of asymmetry varies with the thoracic shape of the species. For the lungs of brachiators the functional inequality is slight because the greater volume of the anterior segments mollifies the spatial restrictions imposed on the lower left lobes by the sinistral position of the heart. The weight of the right lung in man is approximately 53–54 per cent of the total lung weight (Miller, 1947; Spitzka, 1904).

All the small mammals examined displayed a more decided asymmetry owing, in part, to the conical shape of the thorax, but mainly due to the twofold effect of a more eccentric heart position. Any degree of repression incurred by the left lung through laterad cardiac displacement is compensated by the simultaneously permitted medial extension of posterior right stem derivatives. In *Blarina*, where sinistrocardia is most pronounced, the mediastinal and right posterior lobes have come to occupy considerable space left of the median line. For six *Blarina* the wet weight of the right lung (excluding the apical lobe as it is derived from the trachea) averaged .152 gm. against .057 gm. for the left lung. Thus, 73 per cent of the respiratory area posterior to the bifurcation is served by the right stem bronchus. Analysis of corrosion casts also demonstrated this unilateral emphasis. The right bronchus suggested a slightly deflected continuation of the trachea, while the left, though more similar to the trachea histologically, appeared equivalent in size to a secondary branch with the carina placed to the extreme left.

The greater functional and structural predominance of the right stem and its derivatives would accentuate the deflection of aspired matter to the extremities of the right stem where the diverticula may assist in its collection and elimination.

In regard to the fossorial activity of *Blarina*, with its sensory emphasis upon olfaction, the inhalation of particulate substances through its ever-probing snout might well acquire the character of an "occupational hazard." Though the value of the diverticula and the extent of detrimental effects of aspired matter on the lung of the shrew remain in the realm of speculation, an individual in possession of an accessory mechanism that assists in the expurgation of foreign material is, in all probability, also in possession of a selective advantage.

It is believed that the bronchial diverticula in *Blarina* may serve as an example of the process by which morphological innovations become established in the evolution of a species. Though homologous mutations frequently occur in the lungs of other mammals, they would tend to be omitted in subsequent generations by reason of pathological proclivity. But in *Blarina*, the occurrence of muscular variation in conjunction with the fortunate coincidence of location,

in respect to the costophrenic sinus, and the pneodynamics inherent in the bronchial pattern has favored their hereditary preservation.

SUMMARY

The right stem bronchus in *Blarina brevicauda* terminates in two extrapulmonary diverticula which lie, encased by a pleural evagination, in the costophrenic sinus. In a series of one hundred and six specimens, the diverticula were found in all but a single representative of a peninsular subspecies, and were noted to be variable in form. These structures and their proximal bronchi possess a unique musculature comprised of a heavy circular sheath overlying a thin longitudinal layer. Their vascular supply is served by bronchial arteries and drained by bronchial extensions of the pulmonary veins.

Like anomalous homologues found in other mammals, the diverticula accumulate mucus but do not show the pathologic predispositions associated with poor drainage. Because of the exceptional musculature, it is believed that they are capable of peristaltically expelling their contents, and then may assist in the collection and elimination of foreign matter aspired into the right stem bronchus.

Acknowledgement.—The author expresses his deepest appreciation to Dr. Ralph M. Wetzel for his advice and criticism throughout the preparation of this article.

LITERATURE CITED

Bremer, J. L. 1932. Accessory bronchi in embryos; their occurrence and probable fate. Anat. Rec., 54: 361–374.

D'Hardiviller. 1897. Developpment et homologation des bronches principales chez mammiferes (lapin). These, Nancy.

Flint, J. M. 1906. The development of the lungs. Amer. Jour. Anat., 6: 1–40.

Gatenby, J. B. and H. W. Beams. 1950. The microtomist's vade-mecum (Bolles Lee). Blakiston, Phila., (Ed. 11).

Macklin, C. C. 1929. The musculature of the bronchi and lungs. Phys. Rev., 1: 1–60.

Miller, W. S. 1907. The vascular supply of the pleura pulmonalis. Amer. Jour. Anat., 7: 389–407.

———. 1913. The trachealis muscle. Its arrangement at the carina tracheae and its probable influence on the lodgement of foreign bodies in the right bronchus and lung. Anat. Rec., 7: 373–385.

———. 1947. The lung. Thomas, Springfield (Ed. 2).

Narath, A. 1892. Vergleichende Anatomie des Bronchialbaumes. Anat. Anz. Ergan - zundsheft, 7 Jahrg.

Newcomer, E. H. 1953. A new cytological and histological fixing fluid. Science, 118: 161.

Norris, R. F. and R. M. Tyson. 1947. The pathogenesis of congenital polycystic lung and its correlation with polycystic disease of other epithelial organs. Reconstruction of cystic elements in two cases. Amer. Jour. Path., 23: 1075–1088.

Ogilvie, A. G. 1941. The natural history of bronchiectasis. A clinical roentgenologic and pathologic study. Arch. Int. Med., 68: 395–465.

Spitzka, A. 1904. A note on the true weight of human lungs. Amer. Jour. Anat., 3: V.

Department of Zoology, University of Connecticut, Storrs, Connecticut. Received September 14, 1955.

MORPHOLOGY OF THE SCENT GLAND OF THE JAVELINA

By Glenwood P. Epling

The javelina, musk hog, or peccary (*Pecari angulatus*) possesses a single, relatively large scent gland in the mid-dorsal lumbar area, approximately eight inches anterior to the base of its very short tail (Cahalane, 1947). The secretions of this gland are malodorous, and resemble the scent of the skunk (Carter, 1955; Colter, 1955). The gland is present in both sexes, and reaches a diameter of three inches (Camp, 1948), and a thickness of one half inch (Seton, 1937) in mature animals. The secretions may be used as a means of enabling the young to identify their mother (Cahalane, *op. cit.*; Hamilton, 1939; Seton, *op. cit.*), or as a signal device to notify other peccaries of danger. The animals have been observed to rub the gland on low-lying branches, and thus mark a trail for others of their kind. Hunters report that the animals forcibly eject the secretions of the gland at will, and utilize it as a means of offensive protection (Carter; Colter). It has been suggested that the musk may act as a mosquito repellent for the animals, but this is apparently without proof (Seton, *op. cit.*).

Materials and methods.—The specimen studied was removed surgically from an immature two-pound male animal, fixed in 10 per cent buffered formalin, and was bisected. One half of the gland was cut into serial sections seven microns in thickness, and stained with hematoxylin and eosin; the remaining half was dissected.

Morphology.—The gland is embedded in the dermis and subcutaneous fascia of the lumbar region. A single external orifice opens at the summit of a nipple-like elevation (Pl. I, No. 1). This orifice leads into a duct lined with stratified squamous epithelium. The duct opens into a large primary sac (Pl. I, No. 2) which has numerous small ducts leading away from it. Some of these ducts open into smaller secondary sacs, and others are the ducts of apocrine sudoriferous glands. All sacs, and ducts leading from the sacs, are lined with stratified squamous epithelium. Opening directly into the secondary sacs are numerous compound sebaceous glands (Pl. I, No. 3). The sebaceous glands and the sacs, both primary and secondary, are embedded in dense irregular connective tissue. Peripheral to the secondary sacs and sebaceous glands are found the numerous coiled tubular apocrine sudoriferous glands. The sudoriferous glands are embedded in areolar connective tissue. Their ducts spiral in an irregular fashion between adjacent sebaceous glands and secondary sacs to enter the primary sac (Pl. I, No. 3).

Pacinian corpuscles are found in the areolar and dense irregular connective tissue in which the glands are embedded (Pl. I, No. 4), as well as in the adjacent dermis (No. 5). The entire gland complex is surrounded by a well defined capsule of dense irregular connective tissue, which on the deep aspect of the gland is continuous with the epimysium of the striated cutaneous trunci muscle (Pl. I, No. 6).

Discussion.—The fact that the entire gland complex is surrounded by a

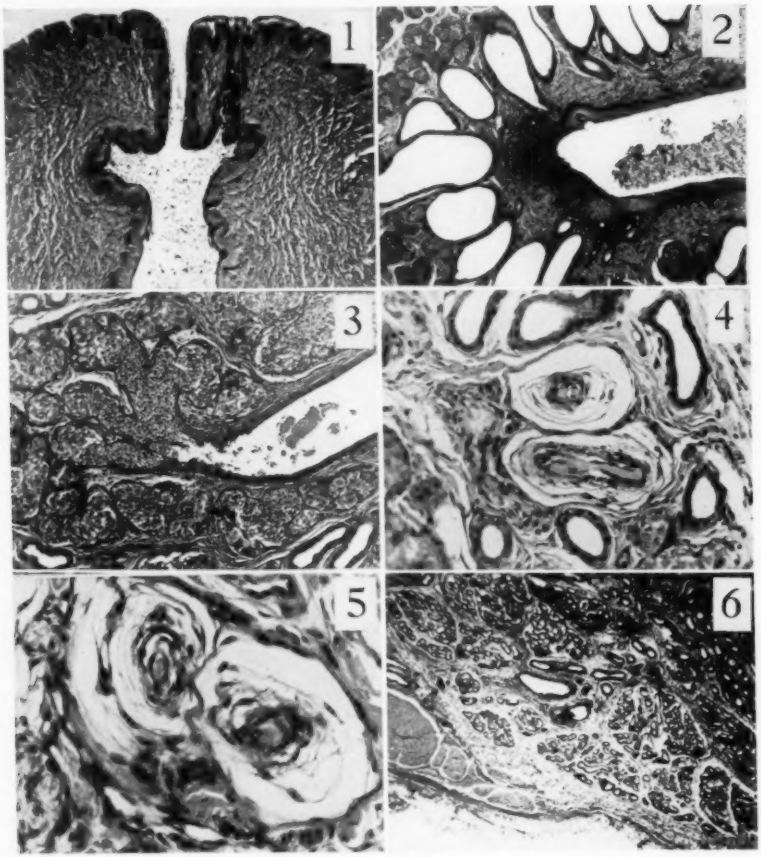


PLATE I

1. The single external orifice opening on a nipple-like elevation. The orifice leads into a duct that in turn opens into a large primary sac. About 15×.

2. The large primary sac surrounded by numerous smaller secondary sacs that open into the primary one. About 15×.

3. Lumen of a secondary sac into which numerous compound sebaceous glands open. The ducts of sudoriferous glands are seen passing between adjacent sebaceous glands en route to the primary sac. About 45×.

4. Pacinian corpuscles surrounded by sudoriferous glands within the gland complex. About 90×.

5. Pacinian corpuscles in the dermis superficial to the scent gland. About 90×.

6. The connective tissue capsule of the gland complex continues as the epimysium of the cutaneous trunci muscle at the left. About 15×.

capsule that attaches to the voluntary cutaneous trunci muscle gives credence to reports that the secretions may be ejected at will.

The presence of primary and secondary sacs in the gland complex leads to the speculation that a mixture of the apocrine sudoriferous and holocrine sebaceous secretions are stored in the sacs until the mass is ejected through the common orifice.

The duration of storage is probably variable. Pacinian corpuscles within and outside of the capsule of the gland complex lead to the assumption that as pressure receptors (Smith and Copenhaver, 1948) they may be responsible for the voluntary emptying of the glands.

Summary.—The scent gland of the javelina (*Pecari angulatus*) is a compound storage gland complex composed of numerous sebaceous and sudoriferous glands that empty their secretions into common storage sacs. The entire gland complex is surrounded by a connective tissue capsule that attaches to the cutaneous trunci muscle. Pacinian corpuscles are found within and adjacent to the organ.

LITERATURE CITED

Cahalane, V. H. 1947. Mammals of North America. Macmillan Co., N. Y. 682 p.

Camp, R. R. 1948. The hunter's encyclopedia. Stackpole and Heck, Inc., Harrisburg, Pennsylvania. 1152 p.

Carter, G. D. 1955. Personal Communication.

Colter, D. B. 1955. Personal Communication.

Hamilton, W. J., Jr. 1939. American mammals. McGraw Hill, N. Y. 434 p.

Seton, E. T. 1937. Lives of game animals. Literary Guild of America, Inc., N. Y.

Smith, P. E., and Copenhaver, W. M. 1948. Bailey's Text-Book of Histology. Williams and Wilkins Co., Baltimore, Md. Ed. 12, 781 p.

Department of Anatomy, School of Veterinary Medicine, Colorado A & M College, Fort Collins. *Received July 1, 1955.*

AGING MEADOW MICE, *MICROTUS CALIFORNICUS*, BY OBSERVATION OF MOLT PROGRESSION

By Dean H. Ecke and Alva R. Kinney

A distinct molt pattern in small rodents has been recognized by investigators for a number of years. Osgood (1909) described three color phases of *Peromyscus* as being due to difference in age but he did not correlate the three phases with specific ages. Collins (1918) found that the progression of molt pattern was consistent in *P. gambeli* as the animal's pelage changed from juvenile to post juvenile and found the change to occur between the 6th and 8th weeks of age. He points out that the molt may be well under way before it is evident at the hair surface. Coventry (1937) compared average sizes with the three principal color phases of *P. leucopus noveboracensis* and *P. maniculatus gracilis*. Pournelle (1952) correlated the "first molt" of *P. g. gossypinus* with age, Hatt (1931) gave a rough age-molt correlation in a captured flying squirrel, and Evans and Holdenried (1943) report that a molt starts in *Citellus beecheyi* soon after the young emerge from their burrows. Storer, *et al.* (1944) from observations of *P. maniculatus* describes ten stages of post juvenile molt, the entire molt requiring from eight to thirty-five days.

For microtine rodents Hamilton (1938) described a definite molt pattern in captive *Pitymys*, the juvenile pelage lasting until about five weeks of age, after which the "adult" pelage first appeared on the sides. A complete change to adult pelage was noted at about seven weeks of age. Larvov (1944) working in Russia, demonstrated two distinct molts in muskrats with a defined pattern in the first year of age and successive molts of no defined pattern occurring continuously thereafter. Kellogg (1946) noted the difference in primeness pattern on muskrat skins and suggested a possible age correlation. Applegate and Predmore (1947) and Shanks (1948), working independently but concurrently, demonstrated a difference in molt pattern on muskrat skins (definite design vs. mottled appearance) between young and old animals and used the distinction as an aging technique on fall and winter fur catches. Errington (1939) found pelage change (molt?) to be as greatly related to size as to age and being quite variable as to age. However, Errington was referring to much more refined aging than either Shanks or Applegate and Predmore.

Goin (1943) was unable to detect molt pattern from external appearance of *Microtus pennsylvanicus* but speculated that time of molt was probably determined by age and physical condition. Hatfield (1935) described two distinct molts in *M. californicus*, one from juvenile to post juvenile beginning about the third week of age, and the second, from post juvenile to adult commencing about the eighth week of age. It was on the basis of Hatfield's earlier study that the present investigation was undertaken.

Epizootic and ecological studies of small rodents require a more refined method for aging than has been previously developed. The widely used categories of "young, subadult, and adult" with their ill defined distinctions are too general

for detailed analysis. A study was undertaken to determine the degree of correlation between age and molt pattern of small mammals. The first species of rodent chosen for study was *Microtus californicus*.

The authors wish to thank Frank M. Prince, Virgil I. Miles and Dr. Jean Linsdale for their advice and review of the manuscript. The photography was done by Virgil Harris of the Santa Clara County Health Department.

Methods.—All animals used in this study were bred in the field and collected together with the mothers as new-born young or as late term embryos. Animals were removed unharmed from live traps and transferred to the laboratory where they were kept in rearing cages. The exact time of birth of all litters but one was known to within 12 hours. The remaining litter was born in the laboratory over a weekend and was aged to within two days. The laboratory mice were fed on oat groats, carrots, and greens and were continuously supplied with free water. Adults were removed from the young at 15 to 25 days from birth depending on the adult's display of intolerance towards the young.

Seven litters of mice were raised for study in 1954 and four litters in 1955. Litter size ranged from one to six. Twenty mice of known age were killed in 1954 and thirteen in 1955. In the complete series, aged skins were obtained from the seventeenth to the fifty-fifth day with one to five day intervals. Care was taken to select specimens so that no litter represented a specific portion of the series. All mice used for study were collected from near Colma, San Mateo County, California, and birth dates ranged from March 26 through May 10, 1954, and from April 17 through May 24, 1955.

The animals were killed in chloroform, sexed, weighed, measured (total, tail, hind foot, and ear) and their exact age in days was recorded. Skins were removed by making incisions on the underside from chin to anus and laterally from the central incision to the extremes of each leg. After removal from the carcass, each skin was stretched and pinned flat to a file card. After drying, the fascia and excess fat were peeled off and the skins were cleaned with carbon tetrachloride. Skulls and front legs were saved and cleaned for possible use in aging.

A brief review of molt pattern as associated with primeness will help to interpret the results of this study. As a new hair develops, a heavy concentration of pigment is deposited at the follicular site. Thus, the skin in the area of new hair growth takes on a dark bluish hue which can be detected from both the fur and underside. As the hair grows, pigment is distributed along the shaft until at full length all pigment is removed from the follicle. The skin at this age appears light, almost milky, and is the condition referred to by fur handlers as prime.

Molt progression.—The first molt (from juvenile prime pelage to post-juvenile pelage) commences from about the twenty-third to the twenty-fifth day of age. At this age mice have reached a length of about 110 to 120 mm. The area immediately ahead of the front legs at the lateral line is first affected. Within one or two days the entire ventral area up to and slightly above the lateral line shows new hair growth (blue color). By the twenty-ninth day the molt has progressed over the top of the rump to about the mid-dorsal spot on the back

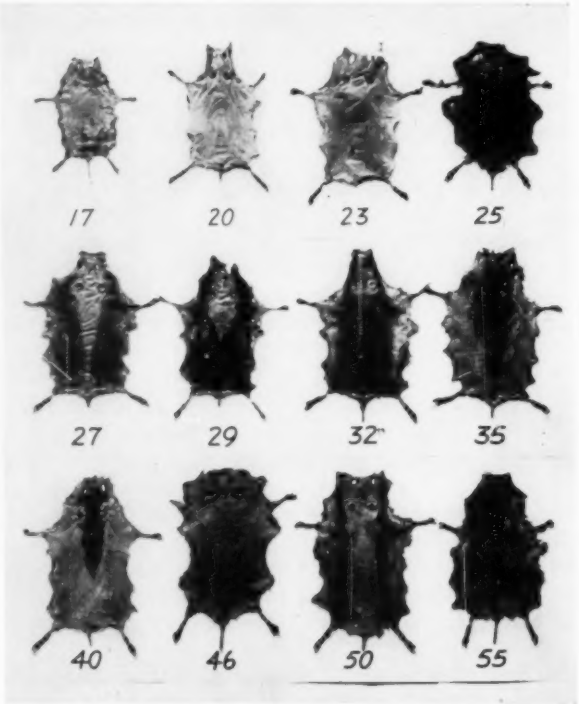


PLATE I

Skins of *Microtus californicus* of known ages, illustrating progression of molt pattern (number beneath each skin designates age in days).

and the hair on the ventral side has nearly completed its growth. Starting about the thirtieth day a white strip of prime skin is evident along the mid-ventral line. The margins of the stretched skin are white and the center resembles a blue cone with the open end at the head. The head area is the last to complete the molt and the skin has become completely prime at about forty-five days of age (Pl. I).

Almost immediately upon completion of the first molt the second (post-juvenile to adult) commences. At fifty days of age the adult hair has started growth over the entire ventral area up to the lateral line or slightly above. As nearly as could be determined the molt pattern for the second molt progresses at about the same rate and in the identical pattern of the earlier molts. On the fifty-fifth day the adult skin is prime except for new hair along the dorsal ridge. The adult skin is probably prime at about the sixtieth day of age. The present series of skins is not complete for this latter molt.

Evidence from skins of old animals indicates that all adult molts (subsequent to the molting of post-juvenile pelage) are irregular. These appear as moltted

TABLE 1.—*Molt phases of Microtus californicus correlated with size and age*

Stage	Juvenile light phase (to full prime)	Juvenile dark phase	Post-juvenile light phase (to full prime)	Post-juvenile dark phase	Adult light phase (to prime)	Post adult molt stages
Description of prepared skins (under side)	Milky white over entire skin. No dark areas.	Blue-black strip along lateral line in early stages. Advanced stages with entire ventral and post dorsal area dark blue. Flat skins contain no white margin.	Ventral area (margins of flat skin) white in early stages. Dark mid-dorsal area receeding towards head, progressing until entire skin white in late stages.	Same as Juvenile dark phase.	Same as Post-juvenile light phase.	Irregular spotting of dark and light areas—no pattern involved.
Number measured*	6	11	9	1	1	1
Maximum and minimum lengths (body plus tail)	92–125	108–145	137–151	148±	160±	?
Average lengths	113 mm.	128 mm.	143 mm.			
Days of age	16–23	23–29	30–47	50± (Probably 47–53)	55± (Probably 54–60)	60+

* Measurements are not included for the four animals that were out of phase or for two more that had lost part of their tails.

patterns of dark and light areas on the underside of the skin with no consistency of design. Table 1 relates the molt pattern with age and size.

Although there is considerable size variation among individuals the total length of an animal will usually key it to one of the molt phases listed in the table. Then by noting whether the molt phase is in the early or advanced stage it is possible to age the animal to within four days of its absolute age. Of the thirty-three animals studied only four were out of molt phase for their respective ages. Two of these were visibly stunted and one was severely injured at birth. Including these animals in the computation for the specimens on hand it is possible to estimate ages to within four days of age with 88 per cent accuracy. No significant molt variation was found between the two sexes.

Skulls saved from these specimens showed that the third upper molar teeth erupted at about twenty days of age. At this age the third lower molar teeth had already erupted. After the eruption of these teeth no subsequent development of skull characters could be correlated with age.

Hale (1949) used the presence of epiphyseal cartilage on the humeri of rabbits to differentiate between young and old animals. It was found during the present study that the epiphyseal cartilage on *M. californicus* humeri persisted well into the adult pelage phase and was therefore of little use in age correlation.

Discussion.—The preliminary results of age-molt correlations of *M. californicus* indicate a remarkable parallel between age and molt design between the twentieth and sixtieth days of age. Aging could be accomplished to within four days in 88 per cent of thirty-three specimens that were reared under laboratory conditions.

With wild specimens of *P. maniculatus*, Storer *et al.* (1944) found the post-juvenile molt to range from eight to thirty-five days. This is a much greater variation than the present study shows for *Microtus*. Subsequent study of wild (field reared) *Microtus* may show a comparable variability. On the other hand, Storer classified his "stages" according to exterior appearance of the animals. Collins (1918) has observed that the molt in some specimens of *Peromyscus* is well under way before it is evident from external appearance. Only additional study of several mammal species under a variety of conditions can determine the accuracy of the molt-aging technique.

In the event that molt pattern correlation proves an accurate aging method it may be desirable to apply it to living specimens. The molt pattern was determined for two animals by clipping small areas of the side, rump and neck. Approximate molt diagrams drawn to completion from these spot (area) checks compared favorably with the actual patterns of the same animals after their skins were prepared. Naturally the accuracy of the method depends on refinement of the individual worker's technique. This method would only be valid for one observation because clipping would upset the normal progression of hair growth. However, if the aged animals were tagged, subsequent aging would not be necessary.

With the possible advantage of determining ages plus the savings in storage space it is suggested to collectors that they preserve their specimens as flat

mounts. Nothing but tradition would be lost and a great deal of additional value would be gained. Also, the flat-mount method requires much less time for preparation than the usual method of study-skin preparation.

Summary.—Thirty-three *Microtus californicus* of known ages were prepared as flat-skin mounts and were studied for age-molt correlation. Preliminary results indicate that a remarkably close correlation exists from the seventeenth to the sixtieth days of age. This age span includes the juvenile and post-juvenile molts. No specific molt pattern is evident in adult animals and the correlation is thereby lost after full adult pelage has been attained—sometime after the sixtieth day of age. A table correlates size with molt pattern and keys the two to specific ages. Six molt phases are described in the table. By placing animals in the early or late stages of these phases they can be aged to within four days of absolute age. The method was 88 per cent accurate with laboratory reared mice.

LITERATURE CITED

Applegate, V. C. and H. E. Predmore, Jr. 1947. Age classes and patterns of primeness in a fall collection of muskrat pelts. Jour. Wildlife Mgt., 11: 324–330.

Collins, H. H. 1918. Studies of normal molt and of artificially induced regeneration of pelage in *Peromyscus*. Jour. Exp. Zool., 27: 73–99.

Coventry, A. F. 1937. Notes on the breeding of some Cricetidae in Ontario. Jour. Mamm., 18: 489–496.

Errington, P. L. 1939. Observations on young muskrats in Iowa. Jour. Mamm., 20: 465–478.

Evans, F. C. and R. Holdenried. 1943. A population study of the Beechey ground squirrel in central California. Jour. Mamm., 24: 231–260.

Goin, O. B. 1943. A study of individual variation in *Microtus pennsylvanicus pennsylvanicus*. Jour. Mamm., 24: 212–222.

Hale, J. B. 1949. Aging cottontail rabbits by bone growth. Jour. Wildlife Mgt., 13: 216–225.

Hamilton, W. J., Jr. 1938. Life history notes on the northern pine mouse. Jour. Mamm., 19: 163–170.

Hatfield, D. M. 1935. A natural history study of *Microtus californicus*. Jour. Mamm., 16: 261–270.

Hatt, R. T. 1931. Habits of a young flying squirrel (*Glaucomys volans*). Jour. Mamm., 12: 233–238.

Kellogg, C. E. 1946. Variation in pattern of primeness of muskrat skins. Jour. Wildlife Mgt., 10: 38–42.

Lavrov, N. P. 1944. Fur structure and molts in *Fiber zibethicus* I. Trans. Central Lab. of Biol. of Game Animals. Peoples Commisariat for Procurement U.S.S.R., 6: 164–183.

Osgood, W. H. 1909. Revision of the mice of the American genus *Peromyscus*. North. Amer. Fauna 8.

Pournelle, G. H. 1952. Reproduction and early post-natal development of the cotton mouse, *Peromyscus gossypinus gossypinus*. Jour. Mamm., 33: 1–20.

Shanks, C. E. 1948. The pelt-primeness method of aging muskrats. Amer. Mid. Nat., 39: 179–187.

Storer, T. I., F. C. Evans and F. G. Palmer. 1944. Some rodent populations in the Sierra Nevada of California. Ecol. Monog., 14: 165–192.

Santa Clara County Health Department, San Jose, California and San Francisco Field Station, Communicable Disease Center, Public Health Service, U. S. Department of Health, Education and Welfare, San Francisco, California. *Received July 30, 1955.*

COLOR PHASES OF THE ROOF RAT, *RATTUS RATTUS*

By James W. Caslick

Widespread confusion regarding the subspeciation of *Rattus rattus* persists among zoologists and others who are concerned with rat control. Although the first volume of the *Journal of Mammalogy* contained a reference to the problem (Miller, 1920), little progress toward its solution has been reported.

In the United States, three subspecies of *Rattus rattus* are widely recognized in accordance to their pelage coloration, as follows: Back brown, belly white—*frugivorus*; back brown, belly dark gray—*alexandrinus*; back and belly both dark gray—*rattus*.

Hinton (1931) recorded his views on the evolution of these subspecies from a form closely resembling *R. r. frugivorus*. Reese (1919) and Anthony (1928) recognized only *R. r. rattus* and *R. r. alexandrinus*; however, the trend toward taxonomic division into the three outlined subspecies has become increasingly strong. Recent government publications describe these forms as separate subspecies (Silver, 1942; Florida State Board of Health, 1951). Field workers have frequently reported black and brown rats sharing the same habitat (Davis, 1947; Barbour, 1950; Storer and Davis, 1953), and intergradation between subspecies has been suggested to explain the occurrence of individuals that do not closely conform to any subspecific type (Anthony, 1928; Davis, 1947; Silver, 1942; Worth, 1950). Worth (1950) reported interbreeding of the three forms in his laboratory, with the resultant litters "exhibiting traits of both parents." Johnson (1946) found a litter of young that included both white-bellied and black individuals in the same nest and concluded that his study population represented three color phases rather than subspecies.

The observations recorded here may partially resolve the kind of relationship existing among the color types. In the laboratory, wild-trapped phenotypes of *R. r. alexandrinus* (brown) and *R. r. rattus* (black) were cross-bred after a month's isolation of the females. As a result of these selective matings, it can now be reported with certainty that littermates may fulfill the requirements of different subspecies and that the occurrence of unclassifiable intergrades is apparently rather rare. The young exhibit a striking difference in the colors of their first pelage; those that later can be classified as *R. r. rattus* first appear to be a uniform glossy black, while those of their littermates destined to fulfill the characteristics of *R. r. alexandrinus* are rufous brown. In addition, there is a persistent dark pigmentation in the naked ears of the black type. Although the genealogy of the parent rats is completely unknown, the litters in Table 1 have been produced in the laboratory.

These breeding results are insufficient to justify the formulation of a sound hypothesis concerning the relative dominance of color, if any, in these forms. However, it does seem somewhat significant that in the four litters of known mixed origin, four-fifths of the young were brown and two of these litters were all brown. This suggestion of a possible dominance of the brown character in

TABLE 1.—*Colors in litters produced by mating various color types of Rattus rattus*

Female	Male	Offspring (parentheses enclose litters)
Brown	Brown	Brown, several litters
Brown	Black	(5 brown) (4 brown) (4 brown, 3 black)
Black	Brown	(3 brown, 1 black)
Black	Black	(1 brown, 10 black) (2 black)

hybridization is further strengthened by the failure of black young to result from several straight brown crosses; since many of these brown parents were trapped alternately with blacks in the same small room at least some of them may have been hybrids, and if there were no color dominance some black young would probably have been produced.

Some doubt has already been expressed as to the propriety of considering the color types to be distinct subspecies (Storer and Davis, 1953). Davis (1947) reported no differences in their habits; Spencer and Davis (1950) noted no differences in the movements or survival of *R. r. rattus* and *R. r. alexandrinus* in Hawaii; Johnson (1946) reported that these types have no morphological distinctions, except for the differences in color.

Considering the breeding results presented here and the biological principle that "two subspecies of the same species do not occur in the same geographic area" (Hall, 1946), it is suggested that the relationship existing between the forms currently recognized as *R. r. rattus* and *R. r. alexandrinus* (and possibly extending to include *R. r. frugivorus*) may be analogous to that which exists between the black and cinnamon phases of the black bear, among the red, silver and cross phases of the red fox, and among the various color phases of the southeastern fox squirrels. Therefore, there may be little justification in continuing to recognize our current forms of *R. rattus* as distinct subspecies when the problem is more satisfactorily resolved by considering them to be only color phases within the species.

SUMMARY

Evidence in the form of breeding results is presented to support the view that the currently recognized subspecies of *Rattus rattus* are only color phases and do not fulfill the requirements for subspecific status.

Littermates of mixed origin may typify different "subspecies."

Limited breeding results indicate a possible dominance of the brown color character in brown-black crosses.

LITERATURE CITED

ANTHONY, H. E. 1928. Field book of North American mammals. Putnams Sons, New York.

BARBOUR, R. W. 1950. The roof rat, *Rattus rattus alexandrinus* (Geoffrey), in West Virginia. Jour. Mamm., 31:461–462.

DAVIS, D. E. 1947. Notes on commensal rats in Lavaca County, Texas. Jour. Mamm., 28: 241–244.

FLORIDA STATE BOARD OF HEALTH. 1951. Rats, the common enemy. Florida Health Notes, May: 90–110.

HALL, E. R. 1946. Zoological subspecies of man at the peace table. Jour. Mamm., 27: 358–364.

HINTON, M. A. C. 1931. Rats and mice as enemies of mankind, Alard & Son, Ltd., London.

JOHNSON, D. H. 1946. The rat population of a newly established military base in the Solomon Islands. U. S. Naval Medical Bul., 46: 1628–1632.

MILLER, G. S. 1920. Recent literature. Jour. Mamm., 1: 146–147.

REESE, A. M. 1919. Outlines of economic zoology, Blakiston's Son & Co., Philadelphia.

SILVER, J. 1942. The house rat. U.S.D.I., Wildlife Circular, 6: 1–20.

SPENCER, H. J. AND D. E. DAVIS. 1950. Movements and survival of rats in Hawaii. Jour. Mamm., 31: 154–157.

STORER, T. I. AND D. E. DAVIS. 1953. Studies on rat reproduction in San Francisco. Jour. Mamm., 34: 365–373.

WORTH, C. B. 1950. Field and laboratory observations on roof rats *Rattus rattus* (Linnaeus), in Florida. Jour. Mamm., 31: 293–304.

U.S.D.I., Fish & Wildlife Service, P.O. Box 131, Gainesville, Florida. Received August 30, 1955.

MAMMALS FROM KURDISTAN, IRAQ, WITH DESCRIPTION OF A NEW BAT

BY DAVID L. HARRISON

During 1954 a small collection of mammals was made by the author in the extreme north of Iraq, which forms part of Kurdistan. This is an extremely mountainous district and the mountain ranges are continuous with those of Asia Minor and Persia. The mammalian fauna is composed of animals which are quite different to those found in the lowlands and desert of which most of Iraq consists and includes many species which are found in Persia, Asia Minor and Syria. It appears to be a faunal element which has been but little studied in Iraq for a number of the species recorded here have not been previously noted as existing in that country. The collection here described was made in the mountains around Amadia, Kurdistan. In this area the mountains are quite extensively covered with scrub oak forest, while the valleys are very fertile and contain poplars and other trees (See Plate 1).

The mammals obtained are listed below, with notes on their characteristics and field habits and with a description of a new bat.

RODENTIA

Meriones persicus Blanford. Persian sand rat.—This large and interesting gerbil is known from Persia, Afghanistan, Baluchistan, Asiatic Turkey, Transcaucasia and Russian Turkestan. It is not known hitherto from Iraq. An adult female specimen was collected at Ser'Amadia, Kurdistan on August 12, 1954, at an altitude of about 6000 feet. The species is readily distinguished by its large size (hind foot 35–40 mm. in the series in the British Museum collection), combined with the completely naked sole of the hind feet and the very heavily tufted tail, which is pale greyish at the tip. The tympanic bulla is relatively small as compared with most members of this genus. From gerbils of the Genus *Tatera*, which also have a robust rat-like form and small bullae, it is distinguished by the more heavily tufted and different coloured tail (black tipped in *Tatera*),

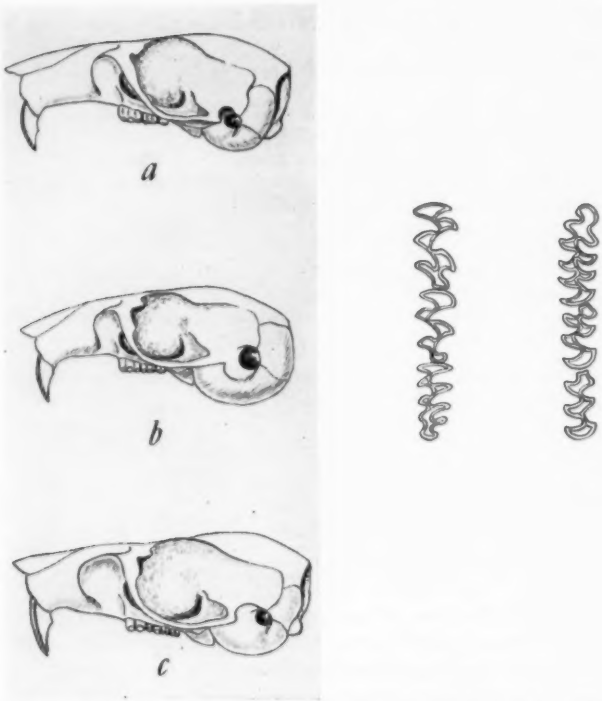


FIG. 1.—LEFT: Skull of (a) *Meriones persicus* compared with (b) *Meriones lybicus* and (c) *Tatera indica*. Side view × 1. From specimens in the Harrison collection.
RIGHT: Cheekteeth of *Microtus socialis* from Ser'Amadia, Kurdistan. (Right side) approx. × 7.

and by the fact that in this species the zygomatic plate is not projected far forwards as in *Tatera*. (Fig. 1.)

The example from Ser'Amadia agrees in size and cranial characters with examples from Persia (specimens from Baluchistan, with slightly larger bullae have been described as a subspecies (*M. p. baptistae* Thomas), but is rather more yellow brown in colour above than any examples from there or Baluchistan in the British Museum collection so that it may prove to represent a different subspecies when more material becomes available for study.

The specimen was trapped with apple as bait during the night at the entrance to its hole beneath a large rock on a grassy mountainside (Pl. I, 1). The species was not uncommon on these slopes and appeared to be strictly nocturnal. Its holes were usually situated beneath rocks but some, believed to have been made by this species, were found in the earthy floor of a tent used as a store of grain for mule food. The specimen was obtained quite near this mule line and numerous grains of corn were found scattered around the entrance of its hole. The animal is well known to the local Kurds, who trap it using raw meat as a bait. An immature animal was found dead, too stale to preserve, at Kani Mase, close to the Turkish frontier, this locality being at a lower altitude.

Cricetulus migratorius cinerascens Wagner. Grey hamster.—One adult and two

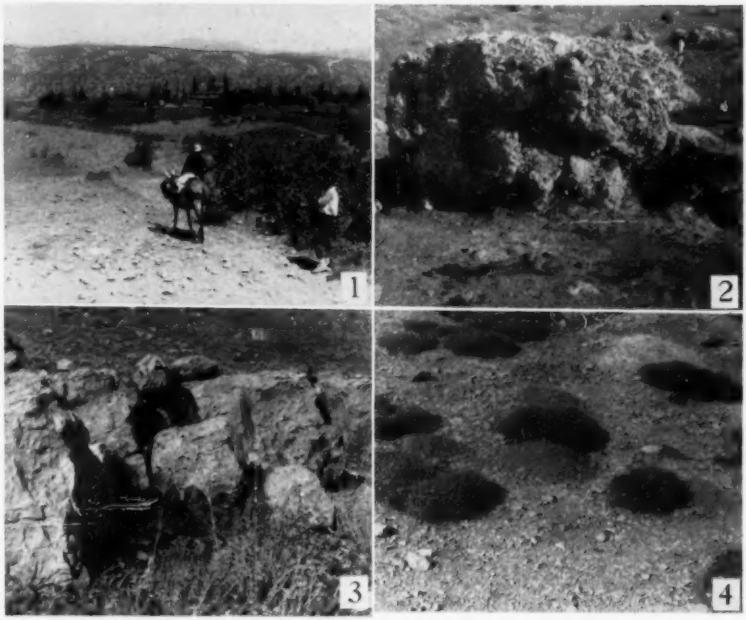


PLATE I

1. Country near Hais, Kurdistan. Photograph by the author.
2. Habitat of *Meriones persicus*. Burrow beneath rock on a high mountain slope at Ser'Amadia. Photograph by the author.
3. Habitat of the grey hamster (*Cricetulus migratorius*) on a mountain slope at Ser'Amadia. Photograph by the author.
4. Earth mounds made by *Spalax ehrenbergi* on high mountain slopes near Ser'Amadia. Photograph by the author.

juvenile grey hamsters were obtained at Ser'Amadia, Kurdistan during early August, 1954. The species is known from the neighbouring territories of Persia, Syria and Asia Minor but does not appear to have been recorded from Iraq hitherto.

It is an abundant species in the area, inhabiting high rock-strewn mountain slopes with abundant short shrubs and vegetation (Pl. I, 3), rather dry at this season. They also frequented our camps and I several times saw them dash round the interior of my tent during the night. The specimens were trapped with cheese as bait. It is noteworthy that the juveniles are much greyer in colour than the adults, which are brownish. The cheek pouches of this hamster are capacious, approximately three centimeters deep.

Apodemus sylvaticus Linnaeus. Long-tailed field mouse.—Two specimens of this species were obtained on August 11, 1954, at Ser'Amadia. The species has not previously been recorded from Iraq. I have not been able to determine the subspecific status of these mice for certain but it seems likely that they represent the race *A. s. arianus* Blanford (1881) with which they agree in having a strikingly white belly. This race occurs in N. Persia and *A. s. witherbyi* Thomas (1902) is now considered a synonym. The race *A. s. tauricus* that Barrett-Hamilton (1900) described from material obtained at Zebil, Asia Minor is stated by Ellerman and Morrison-Scott (1951) to extend into part of Persia.

The race was based on the small size of the skull (Barrett-Hamilton, *loc. cit.*) (21.1 mm. condylobasal length of the Type skull). However there is now a large series of this species from Asia Minor in the British Museum Collection and many of the skulls are considerably larger. A study of the geographical races of *A. sylvaticus* in Southwest Asia is clearly needed to clarify this, and for the present these specimens from Northern Iraq may be doubtfully referred to *A. s. arianus* Blanford.

The species is not uncommon at Ser'Amadia, where it was trapped beneath rocks on mountain slopes at about 6000 feet, with abundant small shrubs and herbs growing there.

Microtus socialis Pallas. Social vole.—One small vole was obtained on August 11, 1954, at Ser'Amadia. This specimen is buffy brown in colour, with a white belly. It is of medium size (hind foot 16.9 mm., condylobasal length of skull 25.2 mm.). It has large tympanic bullae and is therefore referable to *M. socialis* Pallas. This individual possesses a well developed postero-internal loop in M^2 and an unusually complex M^3 with four re-entrant angles internally (Fig. 1). It is clear however, from the work of Ognev (1950) that the structure of this tooth in *M. socialis* is very variable as is also the tendency to development of the postero-internal loop in M^2. It is therefore likely that this will prove to be an individual variation. The species has not previously been recorded in Iraq.

It was trapped using cheese as bait inside a tent, on a high mountain slope covered with grasses and small shrubs, during the night.

Spalax ehrenbergi Nehring. Palestine molerat.—One molerat was obtained on August 4, 1954, at Ser'Amadia and another was received from Tinn, near Bermaneh, near Amadia during early November, 1954.

The taxonomy of this genus is in a somewhat confused state. Ellerman and Morrison-Scott (1951) in their review of the genus, retain three species, *S. microphthalmus* Guldenstaedt, *S. leucodon* Nordmann, and *S. ehrenbergi* Nehring. The latter species is distinguished from the former two by the smaller incisor knob on the lower jaw, which does not project above the level of the condylar process. This species also develops two isolated islands in M^3 as against one in *S. leucodon* and *S. microphthalmus*. This character only develops when the teeth are considerably worn and is hence of no value in the identification of many individuals. The character of the lower jaw does seem to be constant and it is on this account that the present specimens are referred to *S. ehrenbergi* Nehring.

The species occurs in Egypt, Libya, Palestine and Syria. It has not been found in Iraq hitherto and its occurrence there is an interesting extension of its range.

The earth mounds thrown up by these molerats were abundant in the vicinity of Ser'Amadia. They were visible on the high mountain slopes where the ground was very stony (Pl. I, 4) and also more abundantly in the valleys where the soil is richer and more abundant. They were occasionally caught by the local Kurds thrusting a stick in the ground behind the molerat when it was seen throwing up earth. The burrows are evidently very extensive. The stomachs of these two animals contained a greenish vegetable pulp, seed cases, slices of tuberous roots, and in one case the remains of a small insect. One molerat was received by me alive and this animal uttered quiet grunting noises quite unlike the normal rodent squeak. Its Kurdish name is *Quera* and in Assyrian *Khilde*, both meaning "without eyes."

Sciurus anomalus pallescens Gray. Persian squirrel.—One specimen is in my collection obtained in late October, 1954, at Tinn near Bermaneh, Kurdistan. I have found other specimens from Kurdistan collected by the Cox Cheesman expedition, which are in the British Museum Collection, comprising two males and a female from Mergashi, 20 miles north of Dohuk, 2000 feet, obtained in November, 1922 and 1925, and an immature specimen from north of Arbil, December, 1922. I also saw a decapitated skin obtained near Ser'Amadia in August, 1954. The species therefore seems to be well distributed in Northern Iraq, although I can find no published record of its presence there.

The species is distinguished cranially from *S. vulgaris* Linnaeus by the absence of

the small upper premolar. The race occurring in Persia and Northern Iraq is clearly distinct from the typical form, being much paler grey on the back, with a pale rufous tail and pale orange belly. Apparently the ashy grey colour of summer is replaced by a more foxy hue in winter, which is certainly suggested by my specimen that in late October is foxy brown on the head and shoulders and changing to ash grey in the mid-dorsal region.

The employment of the name *pallescens* for this race seems to me to be of doubtful validity, for the Type Locality is unknown, there being no locality on the label of the type specimen in the British Museum Collection. In his original description, Gray (1867) gave its habitat as Asiatic Turkey, but specimens from Asiatic Turkey in that collection are clearly not of this race.

I was informed by the Assyrian from whom I received the specimen from Tinn, that this handsome squirrel usually constructs its nest in trees.

INSECTIVORA

Crocidura suaveolens Pallas. Lesser white-toothed shrew.—A small white-toothed shrew (hind foot 11.4 mm.) was obtained at Bebaidi, near Amadia on August 5, 1954. This shrew is considerably smaller than *C. russula monacha* Thomas (Type Locality, Trebizond, Asia Minor), which has a small skull scarcely exceeding that of *C. suaveolens* in size, but is a more heavily built animal, dark brown in colour, with a very dark belly merging with the back without any line of demarcation. It is also clear that this shrew cannot be referred to the form *C. suaveolens portali* Thomas (Type Locality, Ramleh, Palestine) which is a very pale brown in colour. This individual is a uniform dark brown above with a greyish belly, not sharply delimited. It is the first recorded occurrence of shrews of this genus in Iraq.

The specimen was trapped with cheese as bait, in lush vegetation by the edge of a mountain stream, at the foot of the Sharifa Gorge at Bebaidi village.

Erinaceus europaeus Linnaeus. European hedgehog.—A single specimen of this species was brought to me, having been captured at Hais, Kurdistan on August 22, 1954. It is the first recorded occurrence in Iraq. It is immature, with some milk teeth still in position, and hence its subspecies cannot be determined satisfactorily. The European hedgehog of Palestine and Asia Minor was described as *E. roumanicus sacer* Thomas 1918, and this has been regarded by Ognev as a synonym of *E. e. transcaucasicus* Satunin 1905.

This specimen exhibits a peculiar and interesting deformity of the skull. There is a marked distortion of the facial skeleton, which appears to be due to a failure of growth of the right maxilla that is distinctly smaller than the left. As a result of this the left infraorbital foramen is considerably in front of the right, and the left premaxilla projects in front of the right with an evident twisting towards the right. The right zygomatic arch appears distorted and the right mandible is almost a millemetre longer than the left. This deformity is not due to premature closure of the sutures between the maxilla and neighbouring bones, which are open and normal in appearance on the two sides. There is a backward displacement of the tooth row on the affected side, which has caused a corresponding displacement in the lower jaw.

CHIROPTERA

Miniopterus schreibersi pulcher ssp. nov. North Arabian Long-fingered Bat

Two specimens of this species obtained at Ser'Amadia Kurdistan, Northern Iraq on July 31 and August 6, 1954, are the first record of the species from Iraq. They differ strikingly from the typical form occurring throughout Southern Europe (Type Locality, Kulmbazer Cave, Hungary) and from the race *M. s. pallidus* Thomas (1907), which was described from a specimen obtained on the southern shore of the Caspian Sea in Northern Persia. This race extends into Transcaspia according to Ognev.

Description of the Type.—As Type specimen of this subspecies I nominate an adult

male, (No. 1.1609) in my collection obtained on August 6, 1954, at Ser'Amadia, Kurdistan, N. Iraq. This animal is similar to the typical form in all essential respects but differs so strikingly in colour that no specimen of the typical form in the British Museum collection approaches it. The back is a uniform, very pale greyish colour, closest to drab-grey (No. 13, Plate 2, Ridgway) tinged with hair-brown posteriorly. The back of the typical form is rather darker than broccoli brown. It differs from the Type specimen of *M. s. pallidus* Thomas, which is pale brown on the back, close to wood brown of Ridgway, as strikingly as that race differs from the typical one. The ventral surface is greyish white, the hair bases being dark grey, tipped with white. The typical form is darker on the belly, smoky grey in colour, while *M. s. pallidus* is suffused with buffy brown especially in the inguinal region and along the edge of the interfemoral region.

As Paratype, I nominate an adult male obtained at Ser'Amadia, Kurdistan on July 31, 1954, (No. 2.1610) in my collection. Its colouration is so closely similar to that of the Type as to need no separate description.

Measurements of the Type, taken in the flesh: Total length, 118.2 mm.; forearm, 45.8 mm.; hind foot, 11.5 mm.; tail, 57.9 mm.; ear, 11.9 mm.; wing span, 346 mm.

Skull measurements of the Type: Condylobasal length, 15 mm.; zygomatic breadth, 8.7 mm.; breadth of the braincase, 7.8 mm.; mandible, 10.8 mm.; maxillary tooth row (excluding incisors), 5.7 mm.; mandibular tooth row (excluding incisors), 6.3 mm.

Geographical distribution.—A specimen of this species obtained by the author in the ruins of Jerash, Hashemite Kingdom of Jordan, on October 19, 1953, is also referable to this strikingly pale grey subspecies. It therefore seems likely that this form extends from Kurdistan through Syria to Jordan, but more material is required to elucidate its distribution.

Long-fingered bats were not uncommon at Ser'Amadia where they were obtained when they were flying swiftly along the high mountain slopes. They appeared after dark and were apparently attracted by electric lamps (that were erected on poles to illuminate a mountain path and camp) probably because of the moths which gathered around the lamps. Their flight was exceedingly swift and accompanied by much squeaking. They continued to fly late into the night.

Eptesicus serotinus turcomanus Eversmann, Turkestan serotine bat.—I obtained three specimens of this bat at Ser'Amadia, Kurdistan during August, 1954, and one at Kani Mase, Kurdistan, close to the Iraq-Turkish frontier. The taxonomic status of the bats of this genus in the Middle East is still far from clear. These specimens, however, clearly agree in size and characteristics with a specimen of *turcomanus* from S. Russia in the British Museum Collection, and with three specimens from Persia of *E. mirza* de Filippi, which is regarded as a synonym of *turcomanus*. This bat, which occurs in Persia and Russian Turkestan, has not been recorded from Iraq hitherto. It seems very likely that it will be found to extend into eastern Turkey also. It is slightly larger than *E. kingstoni* Thomas (1919), which occurs along the Tigris and Euphrates in the plains of Iraq, and also differs strikingly in having opaque black ears and membranes, while those of *E. kingstoni* are dusky brown and translucent. The back of *E. s. turcomanus* is also yellower brown in colour. The two forms have not as yet been shown to overlap and in view of the very slight disparity in size I am doubtful whether *E. kingstoni* should be regarded as a race of *E. sodalis* Barrett-Hamilton (Ellerman and Morrison-Scott, 1951). Clearly the Asiatic members of this genus require a full review. It may be noted that these specimens from Kurdistan are slightly paler than Persian specimens.

This bat is quite abundant in the mountains of Kurdistan. Those at Ser'Amadia were obtained after dark while they were flying along high mountain slopes where insects were gathered around electric lamps. The Kani Mase specimen was flying at dusk over a river valley containing poplars and other trees. Its flight is strong, with much squeaking.

CARNIVORA

Martes foina Erxleben. Stone marten.—Two specimens of the marten were obtained alive from a Kurd in August, 1954. They had been captured at Narwa, Kurdistan. Skins

of the marten were displayed for sale in Amadia markets, suggesting that it is not very rare in the district. The species has been recorded from Northwestern Iraq by Sanborn (1940) who mentions a skin from Rowandiz. Owing to paucity of comparative material I have been unable to determine the subspecific status accurately. The form *M. f. intermedia* Severtzov is said to occur in Western Persia. The condylobasal length of this form is given by Ognev (1928) as 81.2–84.6 mm. in males and 78 mm. in a female. The form *M. f. syriaca* Nehring (1902) is smaller, with a condylobasal length of 71 mm. with a narrow, small foramen magnum and strongly developed tympanic bullae. My specimens, which are both females, have condylobasal lengths of 74.9 and 75.2 mm. and their determination is at present doubtful.

Acknowledgments.—I am especially grateful to Mr. M. A. C. Stephenson, who assisted me in the collection and preparation of the specimens and also to Mr. Douglas Carrigan and my many friends in the Royal Air Force Iraq Levies who helped me during my visit to Kurdistan.

LITERATURE CITED

Barrett-Hamilton, G. E. H. 1900. On geographical and individual variation in *M. sylvaticus* and its allies. Proc. Zool. Soc. London, 412.

Blanford, W. T. 1881. On *Mus arianus* from Persia. Ann. Mag. Nat. Hist., (5) 7: 162.

Ellerman, J. R. and T. C. S. Morrison-Scott. 1951. Checklist of Palaearctic and Indian mammals. British Museum Publ.

Gray, J. E. 1867. A synopsis of Asiatic squirrels (Sciuridae) in the collection of the British Museum, describing one new genus and some new species. Ann. Mag. Nat. Hist., 20: 285.

Nehring, A. 1902. On *Mustela foina syriaca* from Syria. Sitzungsberichte Ges. Nat. Freunde Berlin, 145.

Ognev, S. I. 1928, 1931, 1935, 1940. The mammals of eastern Europe and northern Asia. 4 Vols., Moscow.

———. 1950. Mammals of U.S.S.R. and adjacent countries. Vol. 7. Moscow.

Sanborn, C. C. 1940. Mammals from Iraq. Anthropological Ser., Field Mus. Nat. Hist., 30, Pt. 1, No. 1.

Thomas, O. 1902. On five new mammals from Arabia and Persia. Ann. Mag. Nat. Hist 10: 490.

———. 1907. On mammals from N. Persia, presented to the National Museum by Col. A. C. Bailward. Ann. Mag. Nat. Hist., 20: 197.

———. 1919. Some new mammals from Mesopotamia. Jour. Bombay Nat. Hist. Soc., 26: 745.

Bowerwood House, St. Botolph's Road, Sevenoaks, Kent, England. Received August 23, 1955.

NEW APLODONTID RODENT FROM MONTANA OLIGOCENE

By John C. Donohoe

The Chicago Natural History Museum collection of Pipestone Springs Oligocene material contains two jaw fragments, an upper and a lower, originally collected by Dr. E. C. Olson and party in 1941, that represent a new form of rodent. It seems best to describe this form on the basis of these two specimens because the materials from Pipestone Springs are usually fragmentary and the deposits have been sufficiently investigated and reported upon so that it is unlikely that better materials will be soon available.

Although the upper molars of the Pipestone specimen lack the prominent mesostyles that are generally characteristic of the Aplodontidae, the form is assigned to that family on the basis of general tooth structure and tooth relationships. Most of the peculiarities of the dental pattern in this new form are shared with one or another of the early Tertiary genera of aplodontids. The general tooth shape, the posteriorly diminishing tooth row, and the cross-crests and apical basins of the upper molars are all characteristic of the Aplodontidae.

The discovery of an aplodontid in the Montana Oligocene extends our knowledge of the group in two respects. Aplodontids have been described from the Late Eocene and the Early Miocene, but no Oligocene forms have been previously reported. All American records of the family have been from the Pacific coastal states and Nevada.

I wish to thank Bryan Patterson of the Chicago Natural History Museum for permission to study the specimens and Dr. E. C. Olson of the University of Chicago for advice and direction.

Family Aplodontidae Trouessart, 1897

Pipestoneomys, n. gen.

Diagnosis.—Cheek teeth high crowned, rooted, lacking prominent styles or stylids. M^1 and M^2 approximately equal size, quadrangular; M^3 smaller, subcircular. Hypocone and protocone of M^1 and M^2 subequal, separated by a deep persistent groove. Deep groove separating anteroloph and paracone. Trigonid and talonid separated by a deep, persistent groove, mesoconid well-developed. Type species. *Pipestoneomys bisulcatus*, n. sp.

Pipestoneomys bisulcatus, n. sp.

Holotype.—C.N.H.M. UM409—a right maxillary fragment bearing M^1–M^3 from the Pipestone Springs Early Oligocene (Chadronian) deposits, Jefferson County, Montana.

Referred specimen.—C.N.H.M. UM408—a right mandibular fragment bearing dP_4–M_1 from the same locality as the holotype.

Diagnosis.—Same as that for the genus.

Description of the holotype.—M^1 and M^2: The paracone and metacone are distinct, rounded cusps, higher than the remainder of the crown and connected by a lower mesostyle that does not project buccally. The paracone, larger and more buccally situated than the metacone, is separated from the anteroloph by a deep groove communicating with an anteroexternal lake. The protocone and anterocone have been incorporated into the anteroloph and are not distinct cusps. Likewise, the hypocone and metaconule are incorporated into the posteroloph. The protocone and hypocone are subequal in size

and are separated by a deep, median internal groove that communicates with an anterointernal lake. The protoloph and metaloph are incomplete, the former being the stronger structure. The metaconule is broadly fused to the posteroloph and, in a moderate wear stage, may be connected with the mesocone, although a slight separation still exists in M^1 of the holotype. The protoconule is broadly fused to the mesocone, but is separated from the anterocone and the protocone by a persistent groove. In addition to the two lakes previously mentioned there are a posterointernal lake occupying the hypocone pillar, and a posteroexternal lake bounded anteriorly by the protoloph. The latter lake is subdivided into a larger anterior and a smaller posterior portion by the metaloph.

M^3: The third molar has a much reduced hypocone and, in a moderate wear stage, has lost the median internal and the anteroexternal grooves found in the anterior molars. Also, the paracone is a much larger cusp relative to the metacone than in the other molars. The crown has five small lakes similar in position to the five lakes in the other molars.

P^4, a rather diagnostic tooth in aplodontids, is missing in UM409, but the remnants of the alveolus indicate a larger tooth than M^1. The presence or absence of P^3 is indeterminable from the holotype, but a small P^3 is present in the other members of the family.

Description of the referred specimen.—M_1: The metaconid and entoconid are prominent cusps, higher than the remainder of the crown and connected by a lower metastylid that does not project lingually. The metaconid is slightly larger and more rounded in cross section than the entoconid. The protoconid is higher than the anterolophid and, in the unworn condition, may have been a distinct cusp. The anteroconid, hypoconid, and hypoconulid are incorporated into the loph structure and are not separate cusps. There is no separation between the internal cusps and either the anterolophid or the posterolophid. The ectolophid trends posterointernally from the protoconid to the centrally located mesoconid. From the mesoconid a broad mesolophid extends internally to the metastylid. The median external groove separating the protoconid and hypoconid communicates with the posterior, or talonid, lake, and maintains a persistent, narrow separation of the mesoconid and hypoconulid. The anterior, or trigonid, lake is completely enclosed.

dP_4: The deciduous premolar is slightly smaller than M_1 but seems to have the same general structure. The talonid is complete, the trigonid broken in UM408. Further wear

TABLE 1.—*Pipestonecomys bisulcatus n. gen. and n. sp. Measurements of holotype and referred specimen in millimeters*

Measurements	UM409	UM408
Crown lengths		
M^1	1.70	
M^2	1.55	
M^3	0.91	
M^1–M^3	4.37	
Greatest widths		
M^1	1.95	
M^2	1.81	
M^3	1.27	
Crown lengths		
dP_4		1.78
M_1		1.83
dP_4–M_1		3.47
Greatest widths		
dP_4		1.18
M_1		1.69

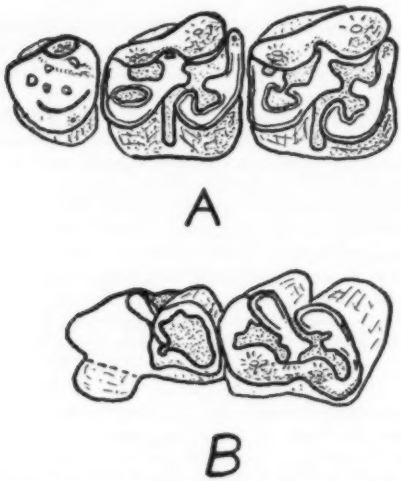


FIG. 1.—*Pipestoneomys bisulcatus* n. gen. and n. sp. A: Right M^1–M^3, crown view, UM409. B: Right dP_4–M_1, crown view, UM408; approx. × 13.9

would isolate small posterointernal and anterointernal lakes from the main talonid lake. The deciduous nature of the tooth is evidenced by the diverging roots, the much lower crown and the more advanced wear stage in comparison to the first molar.

The holotype and referred specimen are illustrated in Figure 1, and measurements of the two specimens are listed in Table 1.

Comparisons.—Comparative materials of other early aplodontids were not available, but *Pipestoneomys* has been compared with the original descriptions and numerous figures of each form. The figures in McGrew (1941) and in Stehlin and Schaub (1951) were particularly helpful.

Pipestoneomys differs from all other described aplodontids in hypocone development, particularly in the deep groove separating the protocone and hypocone. *Allomys* Marsh, 1877, *Sciurodon* Schlosser, 1884, and some species of *Eohaplomys* Stock, 1935, have small hypocones. In the two latter genera there may be a shallow groove separating the protocone from the hypocone, but in neither are the two cusps subequal as in the Montana form. As Wilson (1949) has pointed out, the development of the hypocone as a small cusp may be a matter of little phylogenetic importance, not barring *Eohaplomys* from the ancestry of later forms both with and without hypocones. The much greater development of the hypocone in *Pipestoneomys*, however, seems to preclude it from the ancestry of any forms without hypocones. *Ameniscomys* Dehm, 1950, has a P^4 very similar in shape to the molars of *Pipestoneomys* with a posterointernal corner subequal to the protocone. It is apparently the metaconule, however, that forms this structure.

Another feature that seems to distinguish *Pipestoneomys* from the other aplodontids is the deep anteroexternal groove on the upper molars, separating the anteroloph from the paracone. *Ameniscomys* may have had a similar structure, but, in the moderately worn teeth illustrated by Dehm (1950), the groove, if present, has been obliterated and only a closed lake remains. In *P. bisulcatus* these two grooves have resulted in a separation of the protocone and anteroloph from the rest of the tooth crown. This construction is not found in the molars of any other aplodontid. The anterior upper molars of *Pipestoneomys* are longer than wide, a relationship reversed, to varying extent, in the other members of the family. The convex buccal surfaces of the paracone and metacone, and

the considerably larger size of the former, are also characteristics that set the Montana form apart.

In degree of hypsodonty *Pipestoneomys* compares well with *Allomys*, *Meniscomys* Cope, 1879, and *Ameniscomys*, and differs from the more brachydont *Eohaplomys* and *Haplomys* Miller and Gidley, 1918.

Pipestoneomys is similar to *Eohaplomys*, *Haplomys* and *Sciurodon* in the slight development of the styles, which are better developed in *Meniscomys*, *Allomys*, and *Ameniscomys*. The general similarity in size and shape of M^1 and M^2 is shared by *Pipestoneomys*, *Eohaplomys*, *Ameniscomys*, and *Sciurodon*, and that between M_1 and P_4 by all forms for which both these teeth are known except *Meniscomys*. The differentiation between the anterior molars and M^3 in size and shape is shared by *Pipestoneomys* and *Meniscomys*, these two teeth being much more nearly alike in the other forms. Incorporation of the intermediate cusps into the loph structure in the upper molars of *P. bisulcatus* gives a distinctly different appearance to these teeth compared with those of *Eohaplomys* and *Haplomys*. This is perhaps chiefly a reflection of the differences in hypsodonty.

So far as it can be seen in UM408, the masseteric fossa of *Pipestoneomys* extends much further forward than that of *Eohaplomys* as described by Wilson (1949). The main portion of the fossa appears to terminate below the anterior part of M_1, a shallower extension below the middle of dP_4—practically two teeth anterior to the situation in *Eohaplomys*.

A strong mesoconid as a central element of the lower tooth pattern is shared by *Pipestoneomys*, *Eohaplomys*, and *Ameniscomys*. The mesolophid is similarly developed in *Pipestoneomys* and in *Ameniscomys*, but a depression occupies this region in *Eohaplomys* as well as in *Allomys*, *Meniscomys*, and *Sciurodon*. M_1 of *Pipestoneomys* has a complete anterolophid that distinguishes it from the otherwise quite similar tooth of *Ameniscomys*.

A number of single features are shared by the dentitions of *Pipestoneomys* and *Sciurodon*, but the overall appearance of both upper and lower teeth is quite different. The upper molars of *Sciurodon* show a centrally located transverse depression. In *Pipestoneomys* this region is occupied by the mesocone. The lesser degree of hypocone development and the complete, separated metaloph and protoloph in *Sciurodon* are further differences.

Discussion.—The lower jaw, UM409, is referred to *P. bisulcatus* on the basis of size, occlusal relationships, degree of hypsodonty, and similar aplodontid affinities although there is no indication in the CNHM catalogue, or in the 1941 field notes, to indicate that it was associated with the holotype. The fragmentary nature of the Pipestone Springs materials would render any chance of actual association unlikely, but I am satisfied that the lower and upper dentitions represent the same species.

Sciurodon cadurcensis Schlosser may be closer in age to *P. bisulcatus* than any of the other aplodontids. The species is from the Quercy Phosphorites, however, and no more definite age than Late Eocene to Middle Oligocene is given in the literature. *Sciurodon descendens* Dehm is from the Middle Miocene. The slight change during this time interval presents a situation similar to the apparent slow evolution from the American Late Eocene *Eohaplomys* to the Early Miocene *Haplomys*.

Pipestoneomys and *Ameniscomys* are superficially rather more alike than either is to the other aplodontids. As previously mentioned, however, the origin of the posterointernal corner of the molars is apparently different and no direct relationship seems likely.

In the absence of P^4 little may be hazarded regarding the degree of difference between *Pipestoneomys* and the Mylagaulidae. The characteristics that separate *Pipestoneomys* from *Meniscomys* are, in general, the ones in which the latter resembles the mylagaulids and the ones that led McGrew (1941) to consider *Meniscomys* as close to the ancestry of that family.

Pipestoneomys seems to represent an aplodontid with no direct relationships to any of the known members of the family. It could have been descended from a form near

Eohaplomys, with a considerable development of the hypocone, development of the two grooves of the upper molars, and reduction of the mesostyle and parastyle. Other changes, such as the development of a mesolophid and the change to a hypsodont condition would also have been necessary. None of the Early Miocene American aplodontids seems to have been descended from *Pipestoneomys* or any form with similar hypocone development.

The available materials permit no theorizing concerning the habitus of *P. bisulcatus*. The form was apparently rare at Pipestone Springs, a deposit from which abundant remains of small mammals have been recovered. Whether this rarity is due to differential preservation because of ecological differences or to an actually smaller population of *P. bisulcatus* compared to the other Pipestone Springs rodents is unanswerable. The known fauna from this locality contains many kinds of rodents which must have occupied many different ecological niches. The Pipestone Springs population of *P. bisulcatus* could have been near the eastern edge of the specific range, judging from the distribution of other Tertiary and Recent aplodontids.

LITERATURE CITED

COPE, E. D. 1879. On some characters of the Miocene fauna of Oregon. Proc. Amer. Phil. Soc., 18: 63–78. (also Pal. Bul. 30: 1–16)

DEHM, R. 1950. Die Nagetiere aus dem Mittel-Miocan (Burdigalium) von Winterhof-West bei Eichstatt in Bayern. Neues Jahrbuch fur Mineralogie, Geologie und Palaontologie, 91 (B): 321–428.

MARSH, O. C. 1877. Notice of some new vertebrate fossils. Amer. Jour. Sci., 15: 249–256.

MCGREW, P. O. 1941. The Aplodontoidea. Field Mus. Nat. Hist. Geol. Ser., 9: 1–30.

MILLER, G. S. AND J. W. GIDLEY. 1918. Synopsis of the supergeneric groups of Rodents. Jour. Washington Acad. Sci., 8: 431–448.

SCHLOSSER, M. 1884. Die Nager des europaischen Tertiars nebst Betrachtungen uber die Organisation und die geschichtliche Entwicklung der Nager uberhaupt. Palaeontographica, 31: 19–161.

STEHLIN, H. G. AND S. SCHAUB. 1951. Die Trigonodontie der simplicidentaten Nager. Schweiz. Pal. Abh., 67: 1–385.

STOCK, C. 1935. New genus of rodent from the Sespe Eocene. Bul. Geol. Soc. Amer., 46: 61–68.

WILSON, R. W. 1949. Additional Eocene rodent material from southern California. Carnegie Inst. Washington, Publ. 584: 1–25.

Walker Museum, Department of Paleozoology, University of Chicago, Chicago, Illinois.
Received June 24, 1955.

GENERAL NOTES

A PLEA FOR AN ADEQUATE COLOR STANDARD

Until the appearance of Ridgway's COLOR STANDARDS in 1912 descriptions of mammalian coloration were rather vague affairs at best. That work, however, gave to taxonomists a tool that, though it has its shortcomings, provided a widely available reference for stability in color nomenclature. Though the book has been long out of print it is still the accepted standard.

Anyone who has undertaken to prepare a type description, however, will agree that oftentimes a specimen is seen that has not even a close counterpart in Ridgway. The roundness of a study skin, with its attendant modifying effect on reflected color also contributes to the at times frustrating difficulty in color matching. These facts, of course, are nothing new, and have been repeated in several papers in past years.

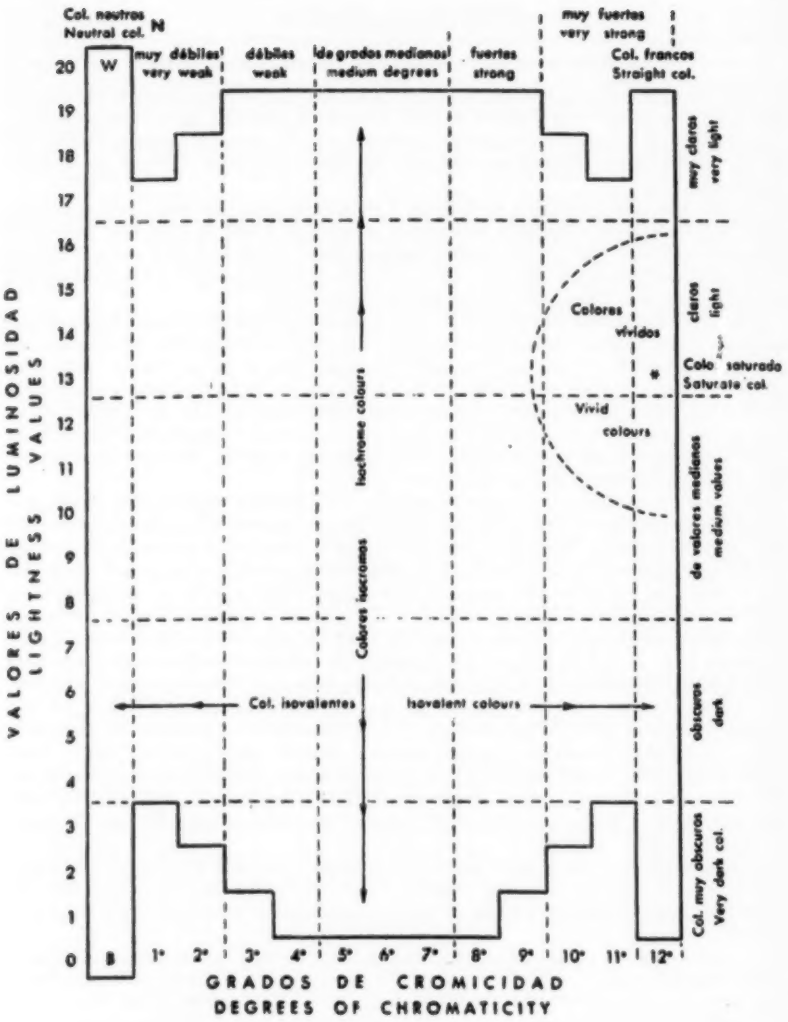
I thought I had solved this problem, in part, at least, by viewing the color plate and skin under low power of a binocular microscope, with the focus set so that both were visible only as contiguous fields of homogeneous colors, neither being in focus (Davis, 1956). This achieved, I thought, close to the ultimate in comparison, since, by eliminating texture, the colors alone could be considered. Unfortunately there was no color in Ridgway really close to the specimen to be described. Comparison, both under magnification and with the naked eye, of specimens seen by Jackson (1928) and his Ridgway notations were characterized by a discouraging lack of correlation.

Recourse to description of a color as "slightly more reddish than Prout's Brown, and darker" is an open door to the situation that Ridgway sought to eliminate. Ideas of "reddish" and the extent of "slightly" vary from person to person, and obviously are not precise enough for taxonomic delineation. While this manuscript was in preparation a criticism was leveled that "since no two people see color alike," any attempt at standardization would forever be useless. I believe that this is a groundless conclusion. If it were true that no two people see the same color in exactly the same way, there is no reason (barring color blindness) to state that each would not recognize the identity of two samples of the same color. And this is precisely the mechanism of Ridgway and the system to be described below. I think that the charge may result at least in part from the inadequacy of Ridgway, wherein a color not exactly matched on the plate may, in desperation or in haste, be noted as a Ridgway color that to some extent approximates it. Several other colors may also be close, and here the matter of personal interpretation enters the picture. One of the sources of the difficulties arising from the use of Ridgway is that the colors there do not vary with sufficient regularity or logic, and that oftentimes the disparity between the two "closest" colors of a series is too great.

Elaborate devices such as are described by Sumner (1927) and Durham (1941), which must be custom made, by their very complexity militate against their widespread use, and would tend to make taxonomy, as far as color nomenclature is concerned, the concern of a very few.

Any new system of standards, to be worthy of adoption must be technically adequate, widely available and not prohibitive in cost. The DICTIONARY OF COLOR by Maerz and Paul, while superior to Ridgway in that it contains many more colors, suffers in that the authors and publishers expressly disclaim absolute standardization among different copies of the book. There is another work of recent origin, the ATLAS DE LOS COLORES by C. and J. Villalobos, that ought to receive far more attention than it has to date. The original text is accompanied by an English translation with directions for use and theory. The high degree of perfection of this work consists of the following qualities.

1. The colors, in issues stamped by the authors, are guaranteed to be "identical to those of any other copy equally guaranteed." There are 7279 colors (1115 in Ridgway). These vary logically and are arranged for better comparison, a single hue to each plate, varied in two directions, from light to dark (value) and from weak to strong saturation (Fig. 1).



XV

FIG. 1.—Pattern for broad designations of colors in the ATLAS DE LOS COLORES. This arrangement is found for each of the 38 subdivisions of pure hues covering the visible spectrum. Reproduced by permission of the publishers.

2. The plates may be temporarily removed for greater ease in comparing plates with one another or with the specimen to be matched.

3. Each square of color is perforated with a hole about four millimeters in diameter. The plate may be placed directly over a specimen and the pelage color viewed through the

plate in the same plane with the comparison color, and contiguous with it. A heterogeneous pattern, such as is found in the gray fox, may be viewed at a distance through the aperture, and its overall color determined. Individual hair colors may be compared in the usual manner.

Barnes (1949) laments the use of numerical color designation as found in Maerz and Paul and used by Gardner (1948). But who can entertain any serious notion that "Prout's Brown," (to stay with one color) conveys any more indication of actual color than does OOS-5-5°, its equivalent in the Villalobos ATLAS, once the reader is informed that the color is a brown. "A more reddish tint than Prout's Brown, and slightly darker," a wild extrapolation from Ridgway, is in the ATLAS OOS-3-2°. Any shade not precisely found in the ATLAS can be notated by a combination of any two colors. A color lying between OOS-3-2° and OOS-4-2° may be written as OOS-3/4-2°. The first and third components of the term may similarly be modified. The use of numbers may very easily be accompanied by a verbal approximation, the color OOS-3-2° being rendered as a rich, dark chestnut color. The reader desiring an exact knowledge of the color is free to consult the ATLAS, as today he must, with less hope of precision, consult Ridgway.

Changeover to the Villalobos ATLAS could be effected smoothly and simply by including in descriptions, until a given date, along with the verbal and numerical description, the most nearly appropriate Ridgway name, with the unhappy adjectival modifiers as needed. Villalobos, incidentally, in an appendix, lists all of the Ridgway names, with their ATLAS equivalent formulas. Several of the colors that I have checked, however (Fawn Color and Chaetura Drab) do not match. Whether the fault lies with the ATLAS or with the Ridgway is hard to say, and Ridgway terms, when not actually compared by an author, ought to be so noted. A sample color description is shown below.

Upperparts a rich dark chestnut color, darker dorsally.

Villalobos: Dorsum OOS-3-2°, shading to OOS-6/7-3° on sides.

Ridgway: Dorsally more reddish and slightly darker than Prout's Brown, becoming approximately Bister on sides.

LITERATURE CITED

BARNES, C. T. 1949. Color nomenclature. Jour. Mamm., 30: 81–82.

DAVIS, J. A. 1956. A new shrew (Sorex) from Florida. Am. Mus. Novitates. (In press)

DURHAM, F. E. 1941. A reflectometer for measuring colors of animals. Jour. Mamm., 22: 199–201.

GARDNER, M. C. 1948. An undescribed cotton rat from New Mexico. Jour. Mamm., 29: 65.

JACKSON, H. H. T. 1928. A taxonomic review of the American longtailed shrews (genera Sorex and Microsorex). North American Fauna No. 51. 238 p.

MAERZ, A. AND M. R. PAUL 1950. A dictionary of color. Ed. 2. McGraw-Hill Co., New York. 206 p., incl. 56 pl.

RIDGWAY, R. 1912. Color standards and color nomenclature. A. Hoen, Washington. 44 p., 53 pl.

SUMNER, F. B. 1927. Linear and colorimetric measurements of small mammals. Jour. Mamm., 8: 177–206.

VILLALOBOS-DOMINGUEZ, C., AND J. VILLALOBOS. 1947. Atlas de los colores. (Colour atlas) El Ateneo, Buenos Aires. Xv, 74 p., 38 pl.

JOSEPH A. DAVIS, JR., *Department of Conservation, Cornell University, Ithaca, N. Y.*
Received January 12, 1956.

MAMMALS FROM EASTERN NEBRASKA

What may be the first recorded melanistic eastern cottontail, *Syvilagus floridanus mearnsi* was collected by Mr. Lawrence Tietz Route 6, Florence Station, Omaha, Nebraska. The black cottontail, a female, was shot in the early morning of the last day of hunting season January 29, 1955 at the De Soto bend of the Missouri River just north of Fort Cal-

houn, Washington County, Nebraska. The pads of the feet appear to be normal in color. On close examination, a dark gray patch may be seen on the throat which becomes narrow as it extends to the chest region. The animal was mounted by the writer and will be placed on temporary loan for exhibit at the Saint Joseph Museum, Saint Joseph, Missouri.

A mounted black eastern cottontail rabbit, *Sylvilagus floridanus mearnsi*, is in the possession of Mr. Slim Ewing of Paul, Otoe County, Nebraska. The animal was killed on the Missouri River bottoms approximately six years ago and mounted by Joseph Voges, a Nebraska City taxidermist, on whose authority this note is written. The specimen has not been examined by the writer. No other data on this specimen is available.

In rabbits the condition of melanism is extremely uncommon. The writer may do well to quote portions of a letter (June 3, 1955) received from Mr. Donald W. Janes a graduate student at the University of Kansas, Lawrence, Kansas. Mr. Janes furnished the following information relative to melanistic rabbits. "Reference in the literature is scarce. Nelson (North Amer. Fauna, No. 29: 26, 1909), says that melanism is extremely rare in American rabbits. He reports seeing two melanistic specimens, one of *Sylvilagus palustris* and one of *Lepus americanus*. Blair (Jour. Mamm., 17: 197, 1936), reports another melanistic *Sylvilagus palustris*, this one from Englewood, Florida. Orr (THE RABBITS OF CALIFORNIA, 1940), reports a melanistic Audubon cottontail, *Sylvilagus auduboni*, from San Diego County, California. Jones (Jour. Mamm., 4: 174, 1923), reports a melanistic European hare, *Lepus europeus*."

The scarcity of least weasels may justify the report of two specimens recently added to the writer's collection. A least weasel *Mustela rixosa campestris* in brown pelage, with two light gray patches above the right shoulder, was given to the writer by Mr. Fred Wedel of Omaha, Nebraska. The animal, a male, was collected near Columbus, Platte County, Nebraska on January 26, 1953. Method of capture is not known. This specimen was macerating badly when received and made into a study skin.

On March 8, 1955, Mr. Ernest Muller of Clatonia, Gage County, Nebraska brought in a male least weasel *Mustela rixosa campestris*, which was purchased and mounted by the writer for his collection. The specimen was killed by a cat in a large barn stored with baled alfalfa. The only marks on the specimen were those on the head; the skull was pierced by the cat's teeth just back of the eyes. The pelage of this specimen is white, with a small brownish spot above and between the shoulder blades; the top of the head is brown, and there is a small grayish brown patch dorsally at the base of the tail.—RALPH VELICH, *5212 So. 23 Street, Omaha, Nebraska. Received June 10, 1955.*

MAMMALS FROM SADO ISLAND, JAPAN, WITH COMMENTS ON THE STATUS OF *APODEMUS ARGENTEUS*

In carrying cut studies on Korean mammals as potential reservoirs of hemorrhagic fever, it has been necessary to take account also of the mammals of the Japanese islands. On August 6 and 7, 1954, one of us (Jones), in conjunction with a group of Japanese investigators studying scrub typhus, obtained a small collection of mammals from Sado Island, Japan, and these, in combination with several specimens in the collection of the National Science Museum, Tokyo, Japan, are the basis for the present report.

Sado Island lies in the Sea of Japan some twenty-five miles from the coast of Niigata Prefecture, to which it is attached administratively. The island, 330 square miles in area, is broadly S-shaped with two parallel mountain chains on either end and a broad, fertile plain in the center. Mt. Kimpoku (or Kanakita) in the northern chain is the highest point on the island, 3,872 feet. The mountainous parts are, in general, well forested. Rice is the main product of the agricultural areas.

Despite the interesting location of Sado Island, little has appeared in the literature concerning its mammalian fauna. Tokuda (Annot. Zool. Japon., 14: 235–241, 1933) reported four species from the island, *Mogera wogura* subsp., *Rattus norvegicus norvegicus*, *Apodemus speciosus* subsp., and *Microtus montebelli brevicorpus*, the latter being described as new. Later (Bul. Biogeog. Soc. Japan, 4: 89, 1941), he named the field mouse as a new subspecies,

Apodemus speciosus sadoensis, and Kuroda (A MONOGRAPH OF THE JAPANESE MAMMALS. Sanseido Co., Ltd., Tokyo and Osaka, 1940, p. 196) described the mole under the name *Mogera wogura tokudae*. Kishida (Rigakukai, 35: 747, 1936) described a hare, *Lepus brachyurus lyoni*, from Sado. A single carnivore, *Nyctereutes procyonoides viverrinus*, has been reported. These, in so far as we know, are the only mammals recorded from the island.

Comments on five species, three of which are new to the island fauna, are herein recorded. All measurements are in millimeters.

Myotis macrodactylus (Temminck, 1840). Japanese myotis.—Two of these bats were taken by a native of the island on the evening of August 6 in a cave on a steep slope along the shore line of the Sea of Japan, one mile north of Tassha, Senkaku Bay. The two specimens, an adult female and young male, measure, respectively: Total length, 87, 87; length of tail vertebrae, 39, 37; length of hind foot, 12, 11; length of ear from notch, 16, 14; length of forearm (dry), 39.5, 36.9. The male is still in juvenile pelage and is presumably a young of the year.

Miniopterus schreibersii fuliginosus (Hodgson, 1835). Long-winged bat.—Seventeen bats of this species were taken under the same circumstances as above. One practically hairless but nearly full-grown young was among those captured. Average and extreme selected measurements of ten adults, four males and six females, are as follows: Total length, 120.5 (118–122); length of tail vertebrae, 53.8 (52–55); length of hind foot, 10.9 (10–11); length of ear from notch, 12.1 (12–12.5); length of forearm (dry), 47.0 (45.7–48.6); greatest length of skull, 15.9 (15.6–16.2) zygomatic breadth, 9.0 (8.8–9.2); mastoid breadth, 9.15 (8.9–9.3).

We tentatively follow Tate (Bul. Amer. Mus. Nat. Hist., 78: 570, 1941) in referring to Japanese specimens as *M. s. fuliginosus*, the type locality of which is in Nepal.

Apodemus speciosus sadoensis Tokuda, 1941. Japanese field mouse.—Two of these mice were trapped on the morning of August 6 near the base of a small hill, two and one-half miles southeast of Shinmachi. The hill was well overgrown with brushy cover and was bordered at the foot by a small stream and rice fields. Both of these animals, an adult male and female, agree with Tokuda's description, and measure, respectively: Total length, 235, 219; length of tail vertebrae, 119, 100; length of hind foot, 27, 26; length of ear from notch, 17, 16. Two alcoholic specimens from Takachi on the northern coast of the island were received by the National Science Museum in December of 1954.

Apodemus argenteus argenteus (Temminck, 1845). Japanese wood mouse.—An adult female, preserved in alcohol, was received in December of 1954, by the National Science Museum from Takachi. Until additional specimens are available, we tentatively refer this animal to *A. a. argenteus*, the subspecies of the adjacent Honshu mainland.

We agree with Ellerman and Morrison-Scott (CHECKLIST OF PALAEARCTIC AND INDIAN MAMMALS. British Museum, London, 1951. p. 570) that *Apodemus geisha* (Thomas) is almost certainly a synonym of *Apodemus argenteus* (Temminck). We do not agree, however, with Ellerman (THE FAMILIES AND GENERA OF LIVING RODENTS. British Museum, London, 1949. 3: 34–35) that the mice of the Japanese islands are conspecific with the European *Apodemus sylvaticus*. Comparisons of Japanese specimens in the U. S. National Museum from Honshu, Kyushu and Hokkaido with European specimens of *sylvaticus* (*A. s. sylvaticus* from Norway and Belgium) reveal that *argenteus* differs from *sylvaticus* in the following cranial features: Zygomatic notch very shallow, zygomatic plate not protruding forward from zygomatic processes of maxillae (zygomatic notch deep, zygomatic plate protruding conspicuously forward from zygomatic processes of maxillae in *sylvaticus*); skull smaller throughout and less massive; brain case flattened and relatively broad; mesopterygoid fossa relatively and actually wider; lacrimal bone conspicuously smaller. In addition, mammae are 2–2 = 8 in *argenteus*, 1–2 = 6 in *sylvaticus*, and *argenteus* is smaller in body size and has a relatively longer tail. For the above reasons we feel justified in restoring specific recognition to the Japanese mice under the name *Apodemus argenteus*. Judging from the literature, currently recognized subspecies of *argenteus* are as follows:

Apodemus argenteus argenteus (Temminck, 1845). Honshu, Shikoku and Kyushu.

Apodemus argenteus hokkaidi (Thomas, 1906). Hokkaido.

Apodemus argenteus celatus (Thomas, 1906). Oki Island.
Apodemus argenteus yakui (Thomas, 1906). Yakushima Island.
Apodemus argenteus sagax Thomas, 1908. Tsushima Island.
Apodemus argenteus tanei Kuroda, 1924. Tanegashima Island.

Rattus norvegicus subsp. Norway rat.—Three adult rats were taken two and one-half miles southeast of Shinmachi on the morning of August 6 in traps set along a stream course in an area well-removed from human inhabitations. Tokuda (*op. cit.*: 238) recorded them as abundant on the island.

Dr. David H. Johnson, Acting Curator of Mammals, U. S. National Museum, kindly made comparative material available. Representative specimens of species obtained by Jones have been deposited in the latter institution.—J. KNOX JONES, JR., *Department of Entomology, 406th Medical General Laboratory, APO 500, San Francisco, California, and Field Unit, Commission on Hemorrhagic Fever, Armed Forces Epidemiological Board; and* YOSHINORI IMAIZUMI, *National Science Museum, Ueno Park, Tokyo, Japan. (Current address of Jones: Museum of Natural History, University of Kansas, Lawrence.) Received August 1, 1955.*

AN EARLY RECORD OF A MARSUPIAL IN CEYLON

It is a curious fact that European naturalists of the seventeenth and early eighteenth centuries were generally unaware of the existence of the remarkable marsupial fauna of Australasia. Later researches have shown that some members of the kangaroo family (Macropodidae) had already been described by early travelers when the publication in 1773 of the account of Captain Cook's first voyage brought these animals into prominence. Observations made on the coast of western Australia by Pelsart in 1629 and by Dampier in 1699, the captive wallabies in Java recorded by de Bruyn in 1714, and the account of the wallaby of the Aru Islands published by Valentyn in 1726 are now well known.

Major R. Raven-Hart of Colombo, Ceylon, has recently called to my attention still another early reference indicating that some kind of marsupial, possibly a wallaby similar to those seen by de Bruyn in Java, had been carried to Ceylon by the Dutch as early as the 1730's. This account is in a rare book entitled "Allerneuester geographisch- und topographischer Schau-Platz von Africa und Ost-Indien . . . " by Johann Wolffgang Heydt, published at Wilhermsdorff, Germany, in 1744. An annotated English translation of the parts of this book referring to Ceylon, where Heydt spent two and a half years from 1734 to 1737, has recently been published by Major Raven-Hart under the title "Heydt's Ceylon" (Ceylon Government Information Department, pp. 225, pls. 95; 1952 [= 1954]. The pertinent passage, quoted from page 144 of the English translation, is as follows:

"The folk brought also to the Company's Stables a beast, which they called in Dutch "Krauyp in jou moder": it was of yellowish colour, of the size of a large hare, and had below its body a doubly-grown skin like a pouch, into which the young crawl when they have drunk, and can hide themselves so well as if they slept again in the womb, which is really amusing to watch."

The "folk" referred to are the Sinhalese; the place is the Dutch East India Company's stables in Colombo; and the vernacular "Krauyp in jou moder" may be translated as "creep into your mother." Major Raven-Hart, having extensive knowledge of the conditions and people of that time, believes that this animal must have been either a member of a free-living transplanted colony or an individual that had escaped from captivity. In any case, no permanent colony was established.—DAVID H. JOHNSON, *U. S. National Museum, Washington, D. C. Received June 18, 1955.*

KEEPING SHORT-TAILED SHREWS IN CAPTIVITY

Pearson, (Jour. Mamm., 31: 351–352, 1950); Crowcroft, (Jour. Mamm., 32: 354–355, 1951); and Rudd, (Jour. Mamm., 34: 118–120, 1953), have given their methods for keeping shrews in captivity. Using a modification of Pearson's method a colony of short-tailed shrews (*Blarina brevicauda*) was maintained in good health during the summer of 1952.

Instead of Pearson's mixture of hamburg, ground liver and dry commercial dog food, Dr. Ballard's Health Food for Dogs (Regular Flavour) was used for the meat portion.

The shrews thrived on this for several months but did not long survive a rather rough trip back to the laboratory. However, in the fall of 1952, more shrews were live-trapped on the campus of the University of Western Ontario and maintained solely on a diet of Dr. Ballard's Dog Food for as long as 16 months. It should be noted that Dr. Ballard's Dog Food is a commercial canned food that is available in several flavours in Canada.

Almost any container was found to be suitable for housing the shrews, provided that there was sufficient floor space. Wood shavings were provided as litter and either some cotton or a small can turned on its side served as a nest.

The shrews were started on the dog food as soon as they were brought into the laboratory, and ate it readily. Following the initial feeding, they were fed once a day with sufficient food to last until the next feeding. Water was available at all times, as it was found that shrews are very sensitive to shortages of both water and food.

During 1952–53 there were several deaths due to lack of water, and the last two members of the colony died in 1954, 16 months after capture. They had not been fed one weekend, with the result that one killed and ate the other and shortly after it too was dead, doubtless due to starvation. Prior to this the two shrews were apparently in good health.

The modified Pearson's mixture was also used for feeding a single *Sorex cinereus*, which was kept in the laboratory for several months.—PETER M. MANN, *Division of Biology, Ontario Veterinary College, Guelph, Canada.* *Received July 10, 1955.*

POSSIBLE HIMALAYAN COLOR PATTERN IN THE MASKED SHREW

Albinism has been reported a number of times in the short-tailed shrew, *Blarina brevicauda*, and several cases of complete albinism and white spotting are known in American members of the genus *Sorex*. G. M. Allen (Jour. Mamm., 16: 223, 1935) reported an albino *S. cinereus* from Seba Beach, Alberta. Pearce (Jour. Mamm., 15: 67, 1934) reported *S. cinereus* from Marcellus, New York, with a white band encircling the forequarters, and Jackson (N. Amer. Fauna, 51: 20, 1928) mentioned a pure white *Sorex*, probably of the species *tundrensis*, from Shungak, Alaska, and *S. obscurus* with a white chin and throat from Okanagan, British Columbia.

Recently the University of South Dakota Museum received a specimen of *Sorex cinereus* from Gertrude N. Miller of Aberdeen, South Dakota, which appears to be of the color pattern known as Himalaya in the domestic rabbit, *Oryctolagus*. The specimen was collected by Marilyn Evelo on April 26, 1955, 5 mi. W and 2 mi. S Aberdeen, Brown County, South Dakota. It is pure white except for the snout, ears, feet and tail, on all of which the skin and hair are normally pigmented. The color of the eyes is difficult to determine; the pupil appears clear and the iris dark. Castle and Swain (Carnegie Inst. Washington, Publ. 427: 19, 1932) state that in true Himalayans the pupil is pink and the iris is milky gray, though the latter may develop pigment under certain conditions. The Himalayan condition is known to be due to the development of a thermolabile pigment in the extremities after birth owing to the lower temperature of these parts. Castle (Carnegie Inst. Washington, Publ. 23: 70–73, 1905) demonstrated that in rabbits the Himalayan pattern was caused by a gene distinct from that causing albinism and capable of segregation, and Sturtevant (Amer. Nat., 47: 234–238, 1913) used this case as evidence that a unit character may have more than two allelomorphic forms. It is now known that the Himalayan color pattern results from a mutation of the basic color gene C to c^H (Castle, Genetics, 39: 35-36, 1954). This color pattern is known in rabbits, mink, guinea pigs, and domestic cats. Many other mammals have dark extremities as part of their normal color pattern. Cuyler (Jour. Mamm., 5: 130, 1924) mentions a white opossum with pigmented ears, iris, skin of feet, and base of tail. However many opossums have extremities darker than the rest of the body.

It is not possible to prove that the color of the specimen under discussion is caused by the gene c^H, but the animal's pattern resembles the pattern of Himalayan examples of other species in every way except for the color of the eyes. I have found no record of this

color pattern in insectivores.—James S. Findley, *Department of Zoology, University of South Dakota, Vermillion. (Current address: Department of Biology, University of New Mexico, Albuquerque.)* *Received June 11, 1955.*

A RECORD OF *SOREX MERRIAMI* FROM NORTHEASTERN COLORADO

The shrew *Sorex merriami* is so uncommon in the eastern part of its range that the capture of a specimen from northeastern Colorado is of especial interest. On October 15, 1953, Richard G. Van Gelder obtained an adult *Sorex merriami* at Owl Canyon, Larimer County, Colorado (specimen no. 7661, Univ. Illinois). It was taken on an east-sloping hogback, which is covered with piñon, juniper, mountain mahogany, yucca, and grasses. Piñons predominate and form an isolated island of piñon-juniper far north of any similar habitat. Although mammals have been trapped for many years on this area, no shrews have previously been taken. Captured with the shrew were *Peromyscus maniculatus* and *Peromyscus nasutus*.

Owl Canyon is not far from the locality near Laramie in southeastern Wyoming where another specimen of this shrew has been taken (Mickey and Steele, Jour. Mamm., 28: 294, 1947). The specimen from Wyoming has been referred to *S. m. merriami*. The one from northeastern Colorado is quite similar to four specimens of *S. m. leucogenys* from Grand Canyon National Park, Arizona, and differs from these (and approaches *S. m. merriami*) only in being slightly shorter in length than the average of the four and in having a narrower cranium. On a geographical basis, one would not expect the specimen from Owl Canyon to be referable to *S. m. leucogenys*, although the flora of the region is reportedly more similar to that of southern Colorado than that of Wyoming. Until additional specimens of *S. merriami* from northeastern Colorado are available, the subspecific determination is questionable.

Dr. H. H. T. Jackson has kindly verified the specific identification of this shrew.—Donald F. Hoffmeister, *Museum of Natural History, University of Illinois, Urbana.* *Received April 30, 1955.*

MERRIAM SHREW, *SOREX MERRIAMI*, IN COLORADO

An adult female Merriam shrew, *Sorex merriami*, was captured by the authors on July 6, 1955, in Moffat County, northwestern Colorado, 0.4 mi. S. of U.S. 40, beside the road to Juniper Hot Springs (Juniper Springs on most maps, southeast of Maybell). The animal was taken at approximately 6,000 ft. on a dry hillside in the ecotone between sage (*Artemisia*) and juniper (*Juniperus*). The live trap in which the shrew was caught was placed near a hole in the fine sand at the base of a sage bush. The only other small mammals caught in the same trapline were several deer mice (*Peromyscus maniculatus*). The shrew had an enlarged uterus, which would indicate that the animal was in breeding condition or in an early stage of gestation.

The locality for this specimen lies between the eastern portions of the ranges given by Miller and Kellogg (U.S. Nat. Mus. Bul. 205: 17, 1955) for the named subspecies of *Sorex merriami*. The nearest record for the northern population (*S. m. merriami*) is in southeastern Wyoming (Mickey and Steele, Jour. Mamm., 28: 293, 1947), roughly 145 miles northeast of the present record; that for the southern population (*S. m. leucogenys*) is in southeastern Utah, about 200 miles to the southwest (Durrant and Lee, Jour. Mamm., 36: 560, 1955). According to the key presented by Benson and Bond (Jour. Mamm., 20: 350, 1939), the specimen from Colorado belongs unquestionably with the southern population, and does not show intermediate measurements in any of the diagnostic characters as might have been expected. In fact, most of the measurements taken proved to be at, or near, the upper extremes for the species as a whole. Pertinent measurements were (in mm.): total length, 102; tail, 38; hind foot, 13; condylobasal length, 17.1; maxillary tooth row, 6.3; maxillary breadth, 5.2; cranial breadth, 8.8. (The specimen is now in the mammal collection of the Museum of Zoology, University of Michigan, as skin and skeleton.) That this specimen does not show characters intermediate between those of the two populations

raises some interesting questions as to the history of the species, since intergradation between these populations is indicated in the western part of their ranges (Benson and Bond, *loc. cit.*). It is, however, reasonable to assume that the species has a continuous distribution over the range between the subspecific populations as now outlined wherever suitable habitat occurs. The use of ". . . about 40° north latitude . . . " (Benson and Bond, *loc. cit.*) to separate these populations is, of course, no longer valid. Obviously, the complete picture cannot be looked for until more specimens of *Sorex merriami* from as yet unrepresented localities become available. In this regard it is of interest that all of the published records for this shrew, in which sufficient habitat notes have been given, have been from the Upper Sonoran and lower Transition Life Zones, although not always from arid situations (*fide* Hall, Jour. Mamm., 14: 153–154, 1933; Mickey and Steele, *op. cit.*). Vegetational associations including sage, juniper, piñon, yellow pine, or combinations thereof, appear in most of the habitat descriptions. With this in mind, perhaps it will not be difficult to fill out the range of *Sorex merriami* and increase our knowledge of this interesting shrew.—ANDREW STARRETT AND PRISCILLA STARRETT, *Museum of Zoology, University of Michigan, Ann Arbor, Received July 22, 1955.*

MERRIAM SHREW IN NEW MEXICO

The capture of a Merriam shrew, *Sorex merriami*, at Tree Springs, approximately 8,300 feet, on the east side of the Sandia Mountains, Bernalillo County, New Mexico, on October 9, 1955, provides the first record of the occurrence of this species in the state. The nearest record-stations of the shrew are at Rose Peak, Greenlea County, Arizona, (Hall, Jour. Mamm., 13: 259, 1932) and War God Spring, Navajo Mountain, San Juan County, Utah (Benson, Univ. California Publs. Zool., 40: 446, 1935). The present specimen, a first year female, University of New Mexico Mammal Collection No. 719, has the following external and cranial measurements in millimeters: total length, 101; tail, 39.5; hind foot, 12.5; condylobasal length, 16.7; palatal length, 7.3; maxillary tooth-row, 6.5; cranial breadth, 8.3; least interorbital breadth, 3.7; maxillary breadth, 5.4. These measurements agree well with the measurements of *Sorex merriami leucogenys* Osgood given by Benson and Bond (Jour. Mamm., 20: 349, 1939), except for the longer maxillary tooth-row (6.5 as compared with 6.2). Hoffmeister (Plateau, 28(1): 1–5, 1955) noted that specimens of *Sorex merriami* from the Grand Canyon "do not fall entirely within the diagnostic limits (of *leucogenys*) given by Benson and Bond," being smaller in condylobasal length and in cranial breadth. The New Mexican specimen is larger in condylobasal length, palatal length, maxillary tooth-row, and maxillary breadth than any of the known Arizonan specimens. It seems best referred to *S. m. leucogenys*.

Hoffmeister (*loc. cit.*) noted that specimens of *S. merriami* from Arizona were taken in Transition and Canadian Life-zone areas in moist places and not in the arid situations with which this species is usually associated. The specimen under discussion was taken on the edge of a grassy meadow adjacent to a forest of white fir (*Abies concolor*). The most common mammal at this site was *Microtus longicaudus*.—JAMES S. FINDLEY, *Department of Biology, University of New Mexico, Albuquerque. Received January 7, 1956.*

IMMATURE WATER SHREWS FOUND IN A BEAVER LODGE

On May 11, 1954, George Knapp, Superintendent of Summer Brook Rearing Station, and two assistants discovered a nest of water shrews (*Sorex palustris albibarbis*) while tearing out a beaver lodge in Ossipee, N. H. The nest was destroyed; but the four immature shrews in it were preserved and brought to the writer for identification. The following data concerning these specimens are submitted herewith since a literature search revealed a surprising lack of information relative to the young of this mammal.

Knapp reported that the nest, "about four inches in diameter and . . . made of sticks and leaves, was just above the water line in the beaver lodge and about a foot from the top of the lodge."

Average measurements, with extremes, of the four young immature water shrews follow:

Length, 73.5 mm. (72–75); tail, 25.8 mm. (24–27); hind foot, 13 mm. (all); weight, 6.4 gr. (6–6.9).

The two lower incisors on one of the shrews had just become visible. As would be expected, the most noticeable characteristic of these four mammals was the prominent light-colored snout.—HILBERT R. SIEGLER, *New Hampshire Fish and Game Department, Concord, N. H. Received May 31, 1955.*

A THIRD SPECIMEN OF THE SHREW *NOTIOSOREX* FROM OKLAHOMA

Clark (Jour. Mamm., 34: 117, 1953) and Glass (Jour. Mamm., 34: 118, 1953) have reported specimens of *Notiosorex crawfordi* Coues from Pushmataha County (southeastern Oklahoma) and Cimarron County (extreme northwestern corner of Oklahoma Panhandle). A specimen in the Biological Surveys collection of the U. S. National Museum (No. 271959) from the Wichita Mountains Wildlife Refuge, Comanche County, southwestern Oklahoma, provides a third record for the state and another marginal locality of the species. The specimen, a female with slightly worn fourth upper premolar, was trapped December 29, 1941 by Charles H. Rouse in the basement of his residence. External measurements, in millimeters, are: Total length 88, tail vertebrae 26, and hind foot 9. Cranial measurements, taken according to directions of Jackson (North Amer. Fauna, 51: 13, 1928) are: Condylobasal length 16.5, palatal length 6.7, cranial breadth 8.2, interorbital breadth 3.9, maxillary breadth 5.1, and maxillary tooth row 6.3.—CHARLES O. HANDLEY, JR., *U. S. National Museum, Washington, D. C. Received August 6, 1955.*

SUNCUS MURINUS, A RECENT INTRODUCTION TO GUAM

The large musk shrew, *Suncus murinus* (Linnaeus), was first taken on Guam in May, 1953 by the author. This is the first record, to his knowledge, of the species from an oceanic island. It is probable that the shrew was introduced into Guam from the Philippines where it is common. Shrews could easily enter bales or crates of cargo materials on the docks or in warehouses at a Philippine port that were destined for Guam and in that manner be transported to the Island. Once the cargo was offladen in Guam, shrews could escape and reproduce, thus establishing the species. This theory gains support from the fact that the first specimens taken were captured in a warehouse situated near Apra Harbor. Investigations made shortly after the first shrews were found revealed that colonies existed at various places in the harbor area, but none was found elsewhere for over one year. Specimens were sent to the University of California, Davis, California where they were identified by Dr. Robert L. Rudd.

S. murinus makes a rather constant shrill chatter as it runs about, not unlike the sharp twitter of birds. During periods of dry weather when shrews appear to be most active and abundant, the night seems filled with their chorus, which is annoying to some persons. In addition to living commonly in houses, warehouses, and other buildings, the shrews inhabit open, grassy regions and areas covered by a dense growth of weeds, bushes, and similar plants. It also lives in swamps and about the margins of ponds. Ordinarily, it is not aggressive, but if cornered can give a painful bite. Cats often kill the shrews, but have not been observed to eat them. The shrews can be taken alive in cage traps baited with peanut butter, or bread and jelly. By using these or similar foods combined with standard rodent poisons, shrews can be eradicated from buildings easily.

Not much is known concerning breeding habits of *S. murinus* in Guam. Nests containing newly born young are frequently found in open, grassy areas and also beneath or beside large rocks, logs, brush piles, and similar materials. The broods found have averaged four or five. Reproduction appears to take place throughout the year, as young have been found at all seasons.

Limited feeding tests conducted with shrews caged in the laboratory showed that they will eat bread, cake, pastry (rolls, cinnamon buns, etc.), jellies, peanut butter, boiled rice, boiled potato, boiled egg, and a wide range of insect species in all stages. They have been reported to eat chicken eggs. In order to verify this one shrew was caged with an egg, the

shell being slightly crushed on one side. The animal made no attempt to eat the egg and eventually died from starvation.

Reports that shrews had been observed to kill and eat the giant African snail, *Achatina fulica* Bow., were given careful consideration. Guam is overrun with these snails that constitute a serious agricultural pest. Experimental tests were made to verify these reports. Starved shrews held in cages would attack living juvenile snails and were able to cause moderate damage to the shells, but none was actually eaten. One shrew killed a small snail. All shrews caged with snails and denied other foods starved to death.

S. murinus appears to have found a favorable ecological niche in Guam. During the two years since its discovery, the shrew has multiplied with great rapidity and has extended its territory with equal speed. It is now common from Agat to Andersen Air Force Base along the western and northern sides of the Island. It has spread to the interior and is common in the villages of Sinajana, Agana Heights, Ordot, Chalan Pago, Mangilao, and Barrigada. Most of this expansion, probably, is the direct result of population pressure. Some of this rapid extension of territory, however, may be due to shrews transported from one place to another by vehicles. In view of the present heavy populations which exist in the harbor area, it is quite probable that the shrew will eventually find its way to other islands in Micronesia since Guam is the transportation center for the Trust Territory of the Pacific Islands.

The ultimate effect that *S. murinus* will have in the ecology of Guam is difficult to foresee. It is quite likely that the shrew will cause substantial damage to stored goods, particularly processed foodstuffs. It may also prove to be a considerable nuisance around homes by virtue of its noisy habits and offensive odor. Its presence in man's artificial environment should not be entirely without benefit, however, because of the tremendous numbers of insects and other arthropod pests that it consumes. The shrew undoubtedly exerts considerable control over cockroaches and other household pests.—George D. Peterson, Jr., *Department of Agriculture, Government of Guam, Agana, Guam.* *Received May 10, 1955.*

BAT VERSUS ANT

An adult male big-brown bat, *Eptesicus fuscus fuscus* Beauvois, caught on the ground floor of the U. S. National Museum in mid-afternoon on June 23, 1955, bore evidence of an earlier encounter with a large ant. Firmly attached to the bat's cheek, midway between eye and angle of mouth, was the head of an ant, determined by Dr. Marion R. Smith, U.S. Department of Agriculture, to have been from a winged queen of a reddish species of the genus *Camponotus*. Judging by the dimensions of the head of the ant, 2.5 x 3.5 mm., the insect could have been 12 to 15 mm. in length. Ants of this group are characteristically night fliers and may be encountered occasionally by bats in flight. Evidently, in the struggle before it was subdued, the ant locked its mandibles into the cheek of the bat and remained firmly attached in a death grip even after the bat had pulled the body loose from the head. In view of the difficulty I experienced in removing the ant's head with forceps, it is probable that the bat may have carried the memento of its meal for some time.—Charles O. Handley, Jr., *U.S. National Museum, Washington, D. C.* *Received July 17, 1955.*

AN OBSERVATION ON QUADRUPLETS IN THE RED BAT

On June 26, 1955 at about 5:30 PM my attention was called to an animal lying on the ground. Examination showed it to be a red bat, *Lasiurus borealis* Muller. When I turned it over I found four young clinging to the underside. The mother seemed reluctant or unable to move. I placed her on a tree branch.

At first the bat appeared hurt but there were no signs of injury. She made no efforts to flee or to defend her young, other than a slight movement of her head and mouth. In contrast to her inactivity, the young were very active, moving their legs and squirming around underneath her.

The coloration of the mother was a very light reddish brown with silver-grey-tipped

hair on her back. The young, however, were a dark brown, bordering almost on the black in spots.

The mother's overall measurement was 4½ inches. Each young measured approximately 1⅝ inches long. Suitable equipment for weighing was unavailable. Sex determination and complete measurements for each individual were not taken to avoid additional disturbance.

The following morning the bat was gone. I feel that she definitely was not injured and that she flew away in the night. This observation took place at Portage, Wisconsin, in a woods comprised of black walnut, locust, boxelder, and willows.—Ross L. Packard, *408 Jackson Street, Portage, Wisconsin.* *Received July 10, 1955.*

WINTER RANGE OF THE RED BAT, *LASIURUS BOREALIS*

Eight specimens of the red bat, *Lasiurus borealis*, recently collected in West Virginia, Indiana, Illinois, and Missouri during the months of November through February point out the necessity of revising our present concept of the winter range of this species.

The winter range of the red bat is generally thought to be from southern United States south to Bermuda and Mexico. For example, Griffin (Bul. Mus. Comp. Zool., 86: 238, 1940) says that it flies south to the southern states where insect food is available throughout the year. Evidence that we have now accumulated shows that it is not uncommon for red bats to winter in regions where freezing weather is frequently encountered. McKeever (A survey of west virginia mammals, 1951) records two specimens from Pocohontas County, West Virginia, taken at elevations of 2400 and 2500 feet on January 4, 1950. He notes that several others were seen in West Virginia flying in the afternoon of warm days throughout the winter of 1949–1950. He also points out that a red bat was seen flying over Stony Creek, near Sutton, Braxton County, West Virginia, at 3:00 PM on January 18, 1951. Other records of interest from West Virginia are as follows: W. Gene Frum has a specimen of *Lasiurus borealis* that was found alive hanging on a fence post at Ranger, Lincoln County, on February 27, 1952. On November 18, 1954, he shot one at dusk 1½ miles west of Lavalette, Wayne County, and he saw at least one other that evening and one on the previous day. The writers shot a red bat along the South Branch Potomac River, 5½ miles north of Upper Tract, Pendleton County, on March 21, 1953. Several others were seen flying that evening.

R. E. Mumford (personal correspondence) has seen red bats in southern Indiana as late as November 17. On March 3, 1955, he saw 13 and shot two in Harrison County, Indiana. In the late afternoon on November 14, 1953, the writers found red bats to be common in Monroe County, Indiana. About six were seen, and two were shot.

Four days were spent in late November, 1953, camping in Missouri and southern Illinois. The first three evenings were cold, and no bats were seen. However, it got much warmer on November 29, and several red bats were seen flying that evening 1½ miles west of Horseshoe, Saline County, Illinois.

On February 4, 1954, a red bat was shot over a pond in a deciduous woods, 5½ miles south of Reeds Spring, Stone County, Missouri. One other individual was seen. The four previous nights had been spent in this region, but the evenings were cold and no bats were seen. There were freezing temperatures every night during this period.

Swanson and Evans (Jour. Mamm., 17: 43, 1936) record a specimen of a red bat taken from a building in St. Paul, Minnesota, on April 9, 1932.

In the autumn of 1954 we decided to investigate how long red bats remain in the vicinity of Urbana, Illinois. Red bats are common summer residents in this region. Brownfield Woods (owned by Univ. Illinois), three miles east-northeast of Urbana, Champaign County, was chosen as a suitable spot for this project. This is a 55 acre upland tract of virgin deciduous forest that is surrounded by open fields. Observations were made from the road which runs north and south along the east boundary of the woods.

Observations at Brownfield Woods were begun on October 22, 1954. Up to this time the minimum temperature (October 18) had been 38°F. We arrived at the woods on October 22 at 5:15 PM. Red bats appeared within a few minutes and were then seen flying almost con-

tinuously over the road for perhaps fifteen minutes. A total of about six individuals was seen and one was shot. It was noticed that the bats quit flying long before dark. Similar observations were made on October 23 and 24.

November 8, 1954. This was the first warm day after our last visit. There had been considerable freezing weather and some snow in the interim, with the minimum temperature in the woods being 29°F. on November 1. We arrived at 4:30 and stayed until 5:10 PM. One bat was seen. It appeared at 4:51. It flew high about the treetops and over the road for two minutes, then returned to the woods and was not seen again. The temperature at this time was 62°F.

November 11, 1954. The day had been quite warm, with the temperature reaching 66°F. at noon. A red bat appeared at the woods at 4:55 and was shot. No other bats were seen.

The woods were not visited again until April 8, 1955. On this day the temperature reached 66°F. in the afternoon. The minimum of the previous day had been 35°F. Several red bats were seen flying, and two were shot between 6:45 and 6:50 PM. Bats were now flying relatively later in the evening than they had been in late autumn. The temperature at 6:30 was only 52°F. Several red bats were also flying on April 9.

April 12, 1955. It had rained all afternoon and was quite cool by evening. No bats were in evidence at Brownfield Woods.

April 13, 1955. It was clear and much warmer this evening, and bats were flying again. At least six different individual red bats were seen, and one was shot.

At no time between November and April, with the exception of January 2, when observations were not possible, did the evenings seem warm enough for red bats to fly. For this reason it could not be determined whether or not they actually winter at Brownfield Woods. Observations are needed on mild winter days in northern latitudes to determine just how far north this bat does remain in winter. Our observations show that it remains in the vicinity of Urbana, Illinois, long after the first frosts of autumn.

It is of interest that all ten specimens cited in this paper taken during October, November, January, February, and March are males. Perhaps the females winter farther south. A female collected on April 8, 1955, at Brownfield Woods may have been migrating.

There is no question that *Lasiurus borealis* is capable of hibernating, just as are those species of bats that spend the winter in caves in northern latitudes. The writers once put a red bat in a cigar box in a refrigerator and removed it the following day. The bat was found to be in a torpid condition but recovered quickly, showing no ill effects from the chilling. On another occasion, a female red bat was placed in a refrigerator at 3°C. It hibernated successfully and lived in this state for two days, but died on the third. Further experimental work is needed to determine the limits of temperature tolerance in this species.

As a result of these observations, it is felt that the red bat can, and normally does, remain in winter in regions where temperatures frequently drop below freezing. It winters regularly in West Virginia and probably also in Missouri, southern Illinois, and southern Indiana. Apparently a constant environmental temperature is not necessary for hibernation, and unseasonably high temperatures during winter months allow these bats to come out and feed. At such times the bats appear in late afternoon and return to their resting places long before dark. This behavior is probably due to the fact that the temperature drops rather rapidly soon after sunset on these warm days in late autumn and winter.—WAYNE H. DAVIS AND WILLIAM Z. LIDICKER, JR., *Museum of Natural History, University of Illinois, Urbana.* *Received May 30, 1955.*

THIRD RECORD OF THE HOARY BAT IN FLORIDA

The hoary bat, *Lasiurus cinereus* (Beauvois), has been taken in Florida at Gainesville and on Santa Rosa Island according to R. Cooley (Jour. Mamm., 35: 166, 1954). A third specimen, a male, consisting of skin and skeleton, no. 2933 of my collection, was received from Mr. William L. Jennings. He was in charge of collecting bats for the study of rabies through a cooperative program with the Florida State Board of Health and the University of Florida, supported by grants in aid from the National Institutes of Health. The bat

was caught by an unknown person who was picking Spanish moss for sale. The party, who bought the moss and saved the bat for us, stated that it was taken somewhere between Tavares, Lake County and Apopka, Orange County, Florida. It was received alive January 24, 1955, and was kept in a refrigerator at a temperature of about 40°F. where it died three days later. Its external measurements in millimeters are as follows: total length, 136; tail, 58; foot, 11; ear from crown, 10, from notch, 16; thumb, 11; forearm, 55.3; third metacarpal, 59.6; fifth metacarpal, 44.7; tibia, 22; weight, 19 grams. The canines and incisors are quite sharp, presumably indicating that this is a young individual.—H. B. SHERMAN, *Gainesville, Florida. Received May 23, 1955.*

A RECORD OF A SILVER-HAIRED BAT IN A CAVE

On January 23, 1952, a male silver-haired bat (*Lasionycteris noctivagans*) was found hibernating in a shallow cave that had been dug into the St. Peter sandstone cliffs along the St. Croix River near Stillwater, Minnesota. During many visits to this cave over a five-year period, this has been the only bat found, with the exception of a small number of big brown bats (*Eptesicus fuscus*) which normally winter here. It was in a state of hibernation and reacted like the big brown bats that were hanging on the wall nearby. This bat is now No. 549 in my collection.

Records of the silver-haired bats in hibernation are rare. In the last few years two notes have been published on this species in caves from areas in Virginia (Rogers, Nat. Speliological Soc. Bul. No. 14: 63, 1952) and West Virginia (Davis, *Ibid.*) The Virginia record was taken on April 12 and might well represent a spring migrant rather than an overwintering animal. The two specimens from West Virginia were taken in November and again especially if taken early in the month, might be of questionable status. The present specimen was taken at a time when the only possible method of surviving would be prolonged hibernation.—JAMES R. BEER. *Department of Entomology and Economic Zoology, University of Minnesota, St. Paul. Received April 23, 1955.*

ADDITIONAL RECORDS OF *NYCTICEIUS* IN INDIANA

Kirkpatrick recorded the first specimen of the evening bat, *Nycticeius humeralis*, in Indiana (Amer. Midl. Nat., 29: 797, 1943). Since that time nine additional specimens have been recorded (Mumford, Jour. Mamm., 34: 121, 1953). Eight new specimens are recorded here, all shot at dusk near farm ponds in the vicinity of Rexville, Ripley County. One adult female and three juveniles of both sexes were taken on July 12, 1953; two females were taken on May 21, 1954, each containing two 10 mm. embryos; one adult female was taken on June 6, 1954 containing two 20 mm. embryos; and one adult female was taken on July 15, 1954. Average measurements of the adults were: Total length, 99.4(93–106); tail vertebrae, 38.2(34–41); hind foot, 8.6(7–9). Pelage of the juveniles was markedly darker than that of the adults. Average measurements of the three juveniles were: Total length, 79.7(76–84); tail vertebrae, 30.3(29–32); hind foot, 7.3(7–8).—DWIGHT M. LINDSAY, *Department of Biology, Georgetown College, Georgetown, Kentucky. Received April 23, 1955.*

THE POCKETED FREETAIL BAT, *TADARIDA FEMEROSACCA*, IN ARIZONA

The pocketed freetail bat is apparently rare in collections. Shamel (Proc. U. S. Nat. Mus., 78: 13, 1931), when he made a survey of the American members of the genus *Tadarida*, had only nine specimens available from seven localities in the United States and Mexico. These were: Arizona—Fort Huachuca, 1; Coyote Mountains, 1. California—Agua Caliente, 1; mouth of Colorado River, 1 (=Baja California, see Neil, Jour. Mamm., 21: 356, 1940). Baja California—Santa Anita, 1; San Pedro Mountains, 1. Jalisco—Zacoalco, 3. Since Shamel's report the pocketed freetail bat has been reported from four additional localities, two in Mexico and two in southern California. Benson (Jour. Mamm., 21: 26–29, 1940) reported a series of 11 specimens (six males, five females) taken by him the night of April 24, 1939, from a pool of water 1 mi. NW Alamos, Sonora. These bats

were captured by stretching wires across the pool about an inch above the water. Dalquest and Hall (Univ. Kansas Publs., Mus. Nat. Hist., 1: 247, 1947) reported two specimens from 10 km. NNE Antiguo Morelos, Tamaulipas. In California, Neil (*loc. cit.*) found a small colony of this species in a crevice in a boulder in Palm Canyon, Borego Valley, San Diego County (also reported by Krutzsch, Jour. Mamm., 25: 201, 1944). Krutzsch (*ibid.* 410–411 and 413–414) reported a small colony in a rock crevice two miles southeast of Suncrest Store, San Diego County.

I have examined the two specimens reported by Shamel (*loc. cit.*) from Arizona. The one from Fort Huachuca (U. S. National Museum No. 20922) is a female, collected in "1892." The one from Coyote Mountains, 3500 ft., Pima County, Arizona (U. S. National Museum, Biological Surveys Collection No. 209318) is a subadult female taken on September 15, 1915.

In the Museum of the Department of Zoology at the University of Arizona is an adult male, preserved in alcohol, that was taken by the late C. T. Vorhies on October 4, 1940, at Tucson, Arizona.

On the night of April 17, 1954, Lee D. Beatty and I captured an adult male *Tadarida femerosacca* in a net stretched across a shallow pond, 7 mi. E, 2 mi. N Tucson, Pima County, Arizona. On two later evenings, April 20, 1954, and April 22, 1954, at the same place and again by using nets, I captured five additional bats of this species, three males and two females. These bats made no audible vocal sounds until they became entangled in the nets. They then emitted a series of high pitched squeaks that continued for several minutes after they were transferred from the net to a cloth sack.

Benson (*loc. cit.*) found that *T. femerosacca* first arrived at the pool approximately an hour after sundown when it was quite dark. This was true, also, of the bats we captured. Perhaps these bats do not leave their daytime retreats until after dark. Apparently they spend the daytime in a type of retreat not readily accessible to collectors such as rock crevices, as reported by Neil (*loc. cit.*) and Krutzsch (*loc. cit.*). I have not found this species in any of the buildings, caves or mine tunnels where hundreds of *Tadarida brasiliensis mexicana* have been observed. The combination of late-flying habit and inaccessible daytime retreats would make this species appear to be rare to collectors using the usual bat-collecting techniques of visiting daytime retreats and of shooting specimens at twilight. Night collecting at waterholes with nets or wires as reported by Benson, indicate that pocketed freetail bats are much more numerous than the present records indicate.

Grateful acknowledgement is made to the National Science Foundation for a Research Grant, G-333 (Investigations of the Mammals of Arizona), for financial assistance.—E. Lendell Cockrum, *Department of Zoology, University of Arizona, Tucson, Arizona.* *Received May 13, 1955.*

ARTIBEUS LITURATUS IN MORELOS, MEXICO

In the Museum of Natural History at the University of Kansas there is a specimen of *Artibeus lituratus palmarum* Allen and Chapman (No. 28031, KU) taken by Bernardo Villa-R. at Cuernavaca in the state of Morelos. Large size, especially marked in the length of the forearm (more than 65 mm.) and the greatest length of the skull (more than 29 mm.), and the well-furred interfemoral membrane distinguish this species from other kinds of *Artibeus* occurring in Mexico. The forearm of the specimen from Morelos measures 66.8 mm., the length of the skull measures 29.1 mm., and the interfemoral membrane is furred. To my knowledge this is the first record of *Artibeus lituratus* in Morelos; this species was not reported from Morelos by Davis and Russell (Jour. Mamm., 35: 63–80) in their list of the mammals of this state. Cuernavaca is at the northern edge of the arid tropical Balsas Basin. Northward lie high mountains and the elevated Central Plateau of Mexico, both regions with environments that differ greatly from that of the tropical lowlands of Mexico. *Artibeus lituratus* has not been recorded from the Central Plateau. The specimen from Morelos, a female, was taken on May 30, 1947, and contained one em-

bryo which measured 55 mm. in crown to rump length.—ROBERT J. RUSSELL, *University of Kansas, Museum of Natural History, Lawrence, Kansas. Received June 13, 1955.*

THE RIVER OTTER IN OHIO

Little is known concerning the distribution of the river otter (*Lutra canadensis*) in Ohio during pioneer times. Kirtland (Second An. Rept. Geol. Surv. of Ohio, 1838) recorded the species as still being common as late as 1838. Brayton (Rept. on Mammalia of Ohio: 184, 1878) quotes Emory D. Potter of Toledo as saying that the otter was occasionally found in most parts of the State in 1878. Hill (HISTORY OF LICKING CO., OHIO: 176, 1881) mentioned it as occurring in "considerable numbers" in the swamps of Licking County in pioneer days. In the region of Buckeye Lake and Bloody Run, Schaff (ETNA AND KIRKERSVILLE: 97, 1905) states that between 1840 and 1858 "Otter tracks were often seen in the snow as they crossed to and from the Reservoir to the creek." Perrin and Battle (HISTORY OF MORROW CO., 838 p., 1880) mention the tracking of an otter along the east fork of Whetstone Creek, near West Point, Morrow County, and Williams (HISTORY OF JACKSON CO., 1900) gives the year 1874 for the last known record of the species in Jackson County.

Some Ohio mammalogists have long considered the river otter to be extirpated (Thomas and Bole, Mimeo. Bul. No. 1, Ohio State Museum, Dept. of Nat. Hist., 1938), but Enders (Occ. Papers Mus. of Zool., Univ. of Michigan, No. 212, 1930) stated that they bred on the Mohican River at the mouth of Ball Alley Run about 1902. From 1930 to 1940 an occasional otter was seen in Ashtabula and Coshocton counties.

No further records of the river otter came to light until November 28, 1951 when a 12½ pound adult male was caught by a trapper on Captina Creek, Belmont County. The skin of this animal is in the collection of the Wildlife Research Unit at Ohio State University.

Persistent rumors of the occurrence of the river otter, particularly in some of the eastern counties, prompted the Game Section of the Ohio Division of Wildlife to initiate a questionnaire type of survey early in 1955 among the game protectors of the State's 88 counties. This survey yielded three very recent records of the otter in as many different counties, all in eastern Ohio, and one hitherto unknown record for Fulton County in northwestern Ohio. The latter was an adult animal killed by a Mr. Joe Trant in 1920.

The three recent observations are all sight records, as follows: Monroe County, Jerusalem Lake, one otter seen by Messrs. C. L. Wilson and F. C. Sumption in April 1954; Coshocton County, Wills Creek east of State Route 76, one seen by Mr. Everett A. Bailey, game protector, who remarked that an otter was seen at various times in this vicinity from 1950 through 1954; and Ashtabula County, at Harpersfield on the Grand River, one reported seen in 1954.

The several recent records of the river otter, most of them in the eastern part of the State, where habitat conditions are more favorable, may indicate that there is some hope for the restoration of this valuable and interesting fur animal in Ohio.—FLOYD B. CHAPMAN, *Ohio Division of Wildlife, 1500 Dublin Road, Columbus. Received June 13, 1955.*

OBSERVATIONS ON A DOMESTICATED PERUVIAN DESERT FOX, *DUSICYON*

The following observations were made while Mrs. Birdseye and I were living at the Hacienda Paramonga, on the Inter-American Highway 192 kilometers north of Lima, Peru. The Hacienda comprises a large sugar estate occupying the irrigated, combined lower valleys of the Pativilca and Fortaleza rivers. On the west the estate is washed by the Pacific Ocean, on the north and south it is sharply cut off by the nearly plantless desert, and on the east it ascends the river valleys into the dry and rocky foothills of the Andes. The region is rainless but humid, and heavy mists, particularly during the winter, cause total annual precipitation of about one inch.

Dusicyon abounds in this section of the Peruvian coast, being equally at home in the rich cultivated areas, the nearly lifeless desert, the foothills and the bird-rich beaches.

It is largely nocturnal and is frequently seen in car headlights, but I have never seen a car-killed fox. Food of course varies with habitat: rodents, insects, small birds and eggs, poultry once in a while, and such fruits as bananas, guavas, chitimoyas, grapes, papayas and mangoes in cultivated areas; crabs, dead fish and sea birds on the beaches, and the eggs and young of sea birds in the rookeries. What these foxes eat and drink in the waterless and semi-lifeless deserts I cannot guess, except that lizards are more or less available everywhere.

All the young foxes—three litters—with which we have personally come into contact have been born in October or November, and at least one litter was dug from a rocky hillside on the edge of irrigated fields given over to sugar cane and bananas.

In late November, 1953, three *Dusicyon* pups, freshly dug from a hillside den, were offered to the Chief Engineer of Paramonga and refused. My wife and I heard of the pups next day and managed to secure one—a female, which we named Susie. Three days later we located and secured Pepe, one of her brothers, but never did find the third pup.

We guessed Susie to be about ten days old when we acquired her. She was cup-size, well-furred, open-eyed, able to stagger around the room and apparently in perfect health. But she obviously had not had food since being captured, and within hours learned—via the dipped-finger method—to lap diluted evaporated milk. A few days later we substituted boiled cow's milk, and, gradually, small bits of raw beef.

When we acquired Pepe he had apparently not taken any food at all for at least four days, and was extremely emaciated and weak. Also, apparently, he was infested with internal parasites for he frequently sat down on a rug and dragged himself around by means of his fore feet. Although we had no difficulty in feeding him milk he lost strength rapidly and died about 48 hours after he was brought to us. Incidentally, Susie started seat-scratching very soon after seeing Pepe do it, but stopped within 24 hours after he died. So far as we can tell she was not then wormy and has not been since, even though we once observed her dragging her bottom even after she reached maturity. At no time have we given her medication of any sort, yet she has never shown any sign of illness. Today, at the age of about 18 months, she seems physically perfect.

Until Susie was about four months old she lived in our house, going outdoors for a romp only once very three or four days Thereafter for another month she was left at liberty in our large walled patio during the day, and shut up in a small box at night. Then, until our departure in May for a six-weeks trip to the States when Susie was eight months old, she ranged freely in our walled patio except for a visit indoors—where she had the run of our one-story house—each evening for play and food. During our absence from Paramonga she took to our roof, from which she could easily have escaped if she had wished, until our neighbors finally caught and penned her in a small box. When we returned to Paramonga a pen 6′ x 10′ x 6′ was built of light-weight 2″ chicken wire and placed next to the poultry corral at the back of the patio. A wooden typewriter case was added for a kennel, and since then Susie has seemed perfectly contented. We still, when she begs persistently, bring her to the house four or five times a month—in the evening or when the lawnmower, the whirring sound of which literally drives her distracted, is to be used.

Although Susie was captured very young and has never even observed other foxes or dogs, she has shown many traits that must have been purely instinctive. As a pup she always retired to a dark "den" to sleep. Her first such "burrow" was inside the foot-rest of a lounge chair. When that was plugged up she used the low space under a dressing table. On outgrowing that haven she invariably took her naps under a bed or couch; and, when allowed the freedom of our patio, dug shallow burrows in shady corners. Yet now that she is full-grown she sleeps, except on very warm sunny days, on top of her nest box.

With us Susie has from the beginning been as tame as any dog or cat. She greatly enjoys being stroked, and scratched anywhere except on the tail. She recognizes our voices and her own name, and such words and phrases as "scratch?" "no!", "come on" and "want something?"—or at least she knows the meaning of the inflections with which those words and phrases are spoken. Sometimes she will come racing across the yard at

my whistle. But she never obeys unless she wants to, and sometimes completely ignores our blandishments and even our presence. She likes to be picked up by the scruff of the neck or by a hand under her chest, but when she's tired of being petted she fights hard to get away—although she never uses her teeth in such a struggle.

But although Susie has always been remarkably tame with us, and shows a certain complacency in the presence of our gardener or cook, she nevertheless is always "nervous as a fox" and much disturbed by strangers. Sometimes when people whom she does not know approach her pen too closely, she bristles from nose to tail-tip and growls in a most dog-like manner. On the other hand, she is less antagonistic toward children, and sometimes even shows signs of wanting to taste a bare calf or ankle.

Although our fox—unlike a parrot (*Aratinga w. frontata*) living in our big guava tree—is sometimes silent for days at a time, she can make several very different noises, each of which apparently has a distinct significance. Up to the age of about two months, however, her only call was a surprisingly loud high-pitched chatter used to summon help, to protest being shut up for the night or to call our attention for any other purpose. Thereafter she completely lost this chatter, and gradually developed the three very distinct vocalizations that she now uses: a puppy-like whine used to protest our too-near approach when she's eating some particularly toothsome morsel; a dog-like growl for strangers; and a loud two-syllabled call, followed by a whine, when she's requesting food, asking to be taken from the pen, or otherwise demanding attention.

Although wild Peruvian *Dusicyons* are nearly omnivorous, our fox is somewhat more selective. Until about a year old she was fond of cow's milk. Since then, however, she has drunk only water, and relatively little of that. Bananas are the only fruit she will eat, and they compose about one-third of her daily diet. Nevertheless she can readily distinguish between the several varieties that grow in this area, and will eat only the sweetest and most delicate kinds. Bread is another favorite food. Cooked, but not raw, fish is eaten with gusto. Meats of all kinds are always welcome, whether raw or cooked in any manner. The same is true with poultry of all kinds, the raw heads being especially welcome. Small birds of all sorts are quickly eaten, feathers included. Sparrows may be gulped down after being cut into only two or three pieces; but doves are cut up according to a regular pattern —head, neck, wings, forepart of body, legs and then the abdominal region. Large insects are favorite tidbits, and she is adept at jumping after butterflies and moths hovering around flowers. Mice and rats are consumed entirely. But raw eggs are, in Susie's opinion, the most exquisite of all foods, and the one thing she will not permit us to take away from her. She snatches them from our hands, carries them around the pen till she thinks we are not watching, buries them for an hour or two, then bites off one end and licks out the contents.

Susie has been brought up in close contact with chickens, ducks and turkeys, and her pen adjoins our poultry yard. When permitted to run loose she frequently wanders among the hens, seldom bothering them as long as they remain unexcited. But the instant there is a sudden commotion she springs for the most rapidly moving bird, grasps it across the back in the scapula region, and shakes it once, instantly incapacitating the bird and causing it to die quickly from internal bleeding.

Susie's canine teeth are the longest I have ever seen in so small a mammal, the upper ones extending so far below her lower jaw that they are easily felt when she is being scratched.

We have never been able to "housebreak" Susie. When she was living constantly in the house she consistently used a "seeded" newspaper for defecation and urination. But by the time she was adult she had developed the habit of urinating on almost anything that interested her greatly—her rubber ball, excess food, or her water dish. Once, in the patio, we watched her urinate 15 times in rapid succession on a spot where a chicken had been beheaded. We have not, however, observed her scratching dirt over urine or dung and she always defecates at the same area in her pen.

When immature, Susie was as inquisitive, mischievous and playful as any puppy—and

in about the same ways. She tangled knitting materials, chewed furniture, cut shoestrings, repeatedly carried my shaving brush under the couch, and once ate much of a tube of novocaine ointment. From about eight to ten months of age she wore out numerous rubber balls and mice, and even now dashes around her cage carrying a much-chewed rubber ball.

In her play with us she was sudden and rough, but always good natured. Sometimes she would dash from under a bed to ruin a nylon stocking, or stand on her hind feet to fight my fist, and roughness on my part did not discourage her playfulness. Now, at 18 months of age, she plays much less frequently and usually by herself. When loose in the patio she sometimes dashes around madly, apparently just because she likes to run her fastest; and at such times her tail is always fluffed to its fullest. In her pen, if given a dead mouse or bird when not hungry, she may spring on it and toss it around for an hour.—CLARENCE BIRDSEYE, *Paramonga, Peru. Received July 20, 1955.*

ARCHEOLOGICAL EVIDENCE OF THE FISHER IN WEST VIRGINIA

Kellogg (Proc. U. S. Nat. Mus., 84, No. 3022, 1937) lists reports of the former occurrence of the fisher, *Martes pennanti pennanti* (Erxleben), from Raleigh, Upshur, and Wetzel counties, West Virginia. He quotes Surber (Proc. 3rd Annual Meeting West Virginia Fish and Game Prot. Assoc.: 49–56, 1909) who states that the fisher "formerly occurred in some numbers in the black spruce region." The spruce referred to is undoubtedly *Picea rubens* Sarg.

A section of the right mandible of a fisher, preserving the alveoli of the first and second molars, was recovered from the cultural debris of the Globe Hill site (Carnegie Museum site no., 46-Hk-34-1), three miles north of New Cumberland, Hancock Co., W. Va. The site is on a terrace (elev., 820′) overlooking the east bank of the Ohio River. It was occupied by a preceramic archaic Indian people and has been dated typologically at from 2000 B.C. to 1000 B.C. This site was excavated in 1953 by Carnegie Museum under the direction of Dr. William J. Mayer-Oakes.

Skeletal remains of the otter, striped skunk, gray fox, dog, woodchuck, gray squirrel, beaver, muskrat, cottontail rabbit (*Sylvilagus* sp.), elk, and Virginia deer were also recovered from the site.

As, apparently, no specimens of the fisher from West Virginia are extant, the jaw fragment was deposited in the collection of mammals, Carnegie Museum.—JOHN E. GUILDAY, *Carnegie Museum, Pittsburgh, Pennsylvania. Received May 18, 1955.*

UNDERWATER BEHAVIOR OF THE SOUTHERN SEA LION, *OTARIA JUBATA*

Until the recent advent of shallow-water diving equipment observations on the underwater behavior of mammals have been difficult and therefore meager. With the use of modern equipment, a colony of *Otaria jubata* (Gmelin) was observed and photographed underwater during an ichthyological survey in the area of the Galapagos Islands between February 26 and March 4, 1955.

Underwater activity of females and young generally followed the playful pattern observed above water. The bull of the rookery was never observed in a frolicking mood, but seemed content to patrol the area continually barking at the herd. This barking was also carried on under water and was plainly audible to the human ear to a distance of 50 feet.

The sea lions observed accepted the proximity of the skin divers both on the surface and underwater without apparent alarm. The animals seemed to be particularly interested in examining the divers' foot flippers. The one adult bull of the rookery, while freely swimming with the divers, would speed away to attack the moment another male approached. Although underwater visibility was limited to approximately 50 feet, the bull would sense the intrusion and be off on the chase while the stray bull was at times still out of sight of the divers.

Although numerous fishes were swimming in the vicinity at the time, none were mo-

lested by the sea lions during the course of the observation. However, the fishes darted away whenever the mammals approached. Fishes speared by the divers were investigated by the sea lions but not touched. Several sea lions were observed swimming along the bottom running their noses through the sand and pushing up a small furrow as if in search of something; they would do this without bringing the remainder of their body in contact with the sand. Younger sea lions demonstrated considerable activity by executing high speed rolls, banks, and loops underwater. One individual paused in plain view, released a sizeable bubble of air into the water and then recovered it before it had escaped the tip of its nose. This may possibly be a method of rebreathing to prolong the underwater stay. Other sea lions dove through series of ascending bubbles and broke up the pattern with movements of the head that suggested play.

Additional underwater observations would contribute greatly in our understanding of behavior patterns of aquatic mammals. The aqua lung is an apparatus ideally suited for making observations of this type.—CHESTER C. LINDT, *School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, California.* *Received May 4, 1955.*

SPERM WHALES STRANDED ON THE BEACHES OF THE GULF OF CALIFORNIA

Reports of one or even two whales stranded on the beach are not unusual but the stranding of a number of whales at one time is unusual. Two cases of multiple strandings of sperm whales in the Gulf of California, Mexico, have come to my attention in recent years. Mr. Glenton Sykes, City Engineer of Tucson, Arizona, was a member of a fishing party that went to the Gulf of California, near Guaymas, Sonora, Mexico, in April, 1953. While on the trip the party observed nine whales on the beach northwest of Guaymas at a point approximately 80 miles south of Rocky Point, Sonora. Sykes took a series of photographs of the whales, which were scattered along a mile stretch of the sandy beach. The smallest of the group was 35 feet in length, the largest, 44 feet. Copies of the photographs were made available to me. The size, the teeth and the shape of the lower jaw, all readily evident in the photographs, served to identify the whales as sperm whales (*Physeter*). Two of these photographs were published on page 10A of the Arizona Daily Star for Sunday, April 19, 1953.

The second case was reported by an Associated Press release datelined February 13, 1954, from San Diego, California. According to this dispatch, Mr. Marvin Grisby, a pilot from San Diego, California, saw 24 sperm whales stranded in the shallow cove at La Paz, at the southern tip of Baja California, and, two weeks later, at the same place, 34 more sperm whales were stranded.—E. LENDELL COCKRUM, *Department of Zoology, University of Arizona, Tucson, Arizona.* *Received May 13, 1955.*

THE MANATEE ALONG THE GEORGIA COAST

The few accounts of the manatee, presumably *Trichechus manatus latirostris* Harlan, north of the normal range in Florida seem to have been regarded as casual, and that was my own belief until recently, for I had known of no instance when it had been seen in Georgia. The purpose of this note is to detail some new accounts from men I know well.

John L. Martin told me a couple of years ago, that some years earlier he had seen an adult with one young in Jekyll Creek, Glynn County, Georgia. Gustave W. Anderson, when approached obliquely told me the same tale. Louis A. Cole, when asked of manatees in general, recounted the same, and was highly indignant that someone shot at them with a rifle. All of these men worked together for several years. Captain Martin also told of seeing five of them together a few miles up the Little Satilla River. The exact time cannot be placed now, but from my acquaintance with the dredges on which these men worked I believe it would fall between 1940 and 1945.

On June 15, 1955, Lester Ackerman, Randolph Knight, and James B. Floyd saw two

manatees on a small slough at half-ebb on the south end of Cumberland Island. The Georgia-Florida line is less than a half mile away to the southward.

All of the men mentioned have long experience in our coastal waters, and I feel that their accounts deserve credence, in a species as easily recognized as this.

The Satilla River empties into St. Andrew Sound, just south of Jekyll Island, and the St. Marys River runs into the sea through St. Marys Entrance, just south of Cumberland Island.

Quiring and Harlan (Jour. Mamm., 34: 194, 1953) report on the anatomy of a Manatee taken in Miami Bay, and found a number of barnacles about the urogenital and anal regions. Barnacles take some time to grow and are readily killed in fresh water. This fact, and the occurrences listed in this note, make it appear that the species may spend much time continuously in salt water.—Ivan R. Tomkins, *1231 East 50th Street, Savannah, Georgia.* *Received July 22, 1955.*

WOODCHUCK REMAINS IN NORTHERN ARIZONA CAVES

Woodchucks, *Marmota flaviventris*, have been recorded twice in northern Arizona; these were from skeletal remains at archeological sites in the northeastern part of the state (Keet Seel and Woodchuck Cave). Woodchucks are known to be living today no closer than Kane County, Utah. Recent investigations of caves in north-central Arizona, particularly in the Grand Canyon area, have brought to light the remains of woodchucks in five other places and considerably extend the known range of *Marmota flaviventris* southward, indicating that the species was rather widespread in northern Arizona a few hundred years ago. The dated material found in the archeological sites has been placed as recently as A.D. 1300 and some as far back as A.D. 200 ± one hundred years.

The woodchuck localities of Grand Canyon and the Navajo country lie in desert canyons of the Lower Sonoran Life-zone bordering on the Upper Sonoran. Woodchucks today tend to inhabit only higher regions where permanent green vegetation is available. Only one of our collecting sites in Government Cave, Coconino National Forest, at approximately 7,000 feet elevation is comparable to this. The other localities in Arizona are at present climatically unsuitable for the species, and the presence of woodchucks there implies a past period of moister and/or colder climate in northern Arizona.

Grand Canyon localities.—The four caves described here are situated in the Redwall limestone, which forms an escarpment 500 to 600 feet high in the south wall of Grand Canyon, at elevations between 4,400 and 4,800 feet. The locations given below can be found on the east half of the Grand Canyon National Park topographic sheet.

Tse-an Olje is a large limestone cave set high in the face of a spur of the Redwall cliff overlooking the west fork of Cremation Canyon. There are two entrances to this cave. The smaller, more accessible one leads into a series of sinuous passages. A right lower jaw of a woodchuck was found exposed on the dust-covered floor approximately 200 feet within this region of the cave. Since no trace of human occupation or use of the cave was observed, the presence of the jaw can hardly be attributed to Indians.

Cylinder Cave is a shallow limestone cave. It lies in Cremation Canyon about ½ mile south of Tse-an Olje. From the inner end of the principal chamber—a northeast-facing grotto 50 feet long and 30 feet wide—a narrow passageway leads about 25 feet further into the cliff. On the dry rock floor of this passage, parts of the right and left lower jaws of a woodchuck were found. No evidence of man was present.

Tse-an Kaetan is a cave several hundred yards south of Cylinder Cave and is visible from Shoshone Point. The entrance opens into an elongated chamber 150 feet long, averaging 40 feet wide, with a ceiling less than 12 feet high. This chamber is dry. From its inner end a crawlway leads into larger interior rooms which contain dripping water and small pools.

The cave was utilized by Indians, either for religious purposes or as a habitation, perhaps both. Though no definite date has been assigned to this site as yet, the assemblage of artifacts indicates a pre-ceramic culture (prior to about A.D. 750). Woodchuck jaws

were found with artifacts and other bone strewn upon the dry, dusty floor of the crawlway mentioned. While the animal might have been used for fur or food by the Indians, this is not certain. The occurrence of the bones of a mountain goat on the same floor surface suggests, as does the woodchuck, a past climate colder and moister than the present.

Tooth Cave is a short cave in the Redwall cliff of Boulder Canyon, east of Cremation Canyon. The low entrance passageway bifurcates, and in the lower of its branches at a passage depth of about 75 feet from the entrance, part of the left lower jaw of a woodchuck was found lying on the dust of the floor. On the same surface was found also the tooth of an American horse. Although Indians have entered the cave, as shown by juniper torches abandoned in the passage, there is nothing to suggest that they carried in the animals.

North-central Arizona.—Government Cave. Another *Marmota flaviventris*, collected in 1954, is a nearly complete skeleton from this lava tube, located approximately 23 miles west of Flagstaff in Coconino National Forest, Coconino County. The cave exhibits the semi-circular cross-section typical of lava tubes and maintains a diameter of 20 to 30 feet over its length of ¾ miles. A description and map of the cave is given by Park (Museum Northern Arizona, Museum Notes, 2 (no. 6): 1–3, 1929). Being situated at an elevation of about 7,000 feet, the cave remains cold and damp throughout the year (air temperature averaging 40° F.), and icicles can be seen near the entrance as late as July of each year. Sign of Indian use is lacking, but numerous bat and rodent bones indicate that the cave serves as a popular retreat for wildlife.

The woodchuck was found at a passage distance of 1,100 feet from the entrance, amid blocks of lava fallen from the ceiling. The skull of the animal was missing. Porcupines have inhabited this region of the cave, and it seems safe to conclude that the woodchuck did likewise.

Northeastern Arizona.—Woodchuck Cave. Lockett and Hargrave (Museum of Northern Arizona Bul. 26: 33, 1953) have described this shallow sandstone shelter cave set high in the cliff wall of Water Lily Canyon, a branch of Dogoszhi Biko in the Tsegi Canyons of Navajo County. This is a Basketmaker II site, dated by tree-rings as A.D. 200 ± one hundred years. The cave was excavated in 1934 by members of the Rainbow Bridge-Monument Valley Expedition. Woodchuck jaws were found in two cists, accompanying burials. This is the first record of woodchuck reported from Arizona and the occurrence provided the name of the cave.

Keet Seel. This, the largest of the cliff dwellings in Navajo National Monument, Navajo County, was partially excavated and repaired in 1934 under the supervision of the Museum of Northern Arizona (Hargrave, *Museum Notes* 7 (no. 7): 25–28, 1935). Keet Seel, like Woodchuck Cave, is situated in a desert canyon of the Tsegi country, where water and green vegetation are today scarce. It was inhabited by Pueblo III peoples, who abandoned the site about 700 years ago. Here the right lower jaw of a woodchuck was obtained during excavation.

Description of specimens.—The skeletal remains from the localities described above were submitted to Donald F. Hoffmeister of the Museum of Natural History of the University of Illinois for examination.

Except for the partial skeleton from Government Cave, all of the specimens are lower jaws. The material from Tse-an Olje, Tse-an Kaetan, Tooth Cave, and Government Cave is all representative of a typical woodchuck, *Marmota flaviventris*. The cheek teeth of the specimens from Tse-an Olje and Government Cave are about 9 per cent shorter than those from Tse-an Kaetan. The unclosed epiphyses and loose condition of the heads of the long bones from the Government Cave skeleton indicate that this individual had not reached maturity.

The material from Cylinder Cave is somewhat atypical in that the teeth are massive and larger than normal, and the process at the anterior end of the masseteric fossa is overly pronounced.

The three jaws from Cist 15 of Woodchuck Cave represent three individuals all with

well-worn teeth. The teeth of the oldest individual, represented by a left lower jaw, are worn completely smooth. Like the specimen from Cylinder Cave, this jaw has a pronounced protuberance at the anterior end of the masseteric fossa. Cist 1 yielded the right and left lower jaws of one individual, typical of the others of Woodchuck Cave; however, all are smaller than the jaw from Tse-an Kaetan.

The right lower jaw obtained from Keet Seel is slightly smaller than the jaws from Woodchuck Cave.

Acknowledgements.—The Grand Canyon Cave Reconnaissance is a project of the Western Speleological Institute and the Museum of Northern Arizona, and was financed by O. H. Truman. We are indebted to Dr. Hoffmeister for his careful examination of the specimens, to Grand Canyon National Park for their cooperation in the field work, and to the School of Mineral Sciences of Stanford University for the use of their facilities.—ARTHUR L. LANGE, *School of Mineral Sciences, Stanford, California.* *Received May 27, 1955.*

EXTENSION OF THE KNOWN RANGE OF *MARMOTA MONAX* IN ALASKA

During the Summer of 1951, the Arctic Aeromedical Laboratory at Ladd Air Force Base, Alaska, had in its collection of experimental animals a large woodchuck (*Marmota monax*) reported to have been captured on the base. Since the range of this species had not been reported to extend this far northward, an attempt was made to collect additional specimens for study. On July 11, 1952, personnel from the Aeromedical Laboratory observed an old adult and three young together about two miles east of Fairbanks, Alaska; one of the young, a female, was caught by hand.

I am indebted to Dr. Henry W. Setzer for comparing this specimen with material in the United States National Museum and for calling my attention to three other specimens that were taken in the vicinity of Fairbanks and deposited in the U. S. Fish and Wildlife Service Collection. Although our specimen was a young animal whose third molars were only beginning to erupt through the bone lamina in both jaws, Dr. Setzer reported that it agrees in detail with one of the Fish and Wildlife specimens. All are identified as *Marmota monax ochracea* Swarth. The previously reported most northern point in the range of the species appears to be from the type locality of *Marmota m. ochracea*, the head of Forty-mile Creek in eastern Alaska (Swarth, Univ. Calif. Publ. Zool., 7: 201–204, 1911). The occurrence of these woodchucks in the vicinity of Fairbanks represents an extension in their known range of approximately 200 miles to the west-north-west. Locality records on the four museum specimens are as follows: USFW 243607, ♀, Moose Creek, 30 miles above [upstream from] Fairbanks, June 17, 1923, Adolph Murie; USFW 247013, ♂, Fairbanks, May 25, 1926, O. J. Murie; USFW 264418, ♀, near Fairbanks, 1938, J. W. Warwick; NCS 573, ♀ 2 miles east of Fairbanks, July 11, 1952, collector unknown.

The information provided by Mr. Stanley Young on the three specimens in the U. S. Fish and Wildlife Service Collection is sincerely appreciated.—FREDERICK S. BARKALOW, JR., *Division of Biological Sciences, North Carolina State College, Raleigh.* *Received July 5, 1955.*

INVASION OF A LOGGED AREA BY GOLDEN-MANTLED SQUIRRELS

At the southern terminus of their range in northwestern California, golden-mantled squirrels (*Citellus lateralis*) of the subspecies *trinitatis* (Merriam) occupy a narrow, rugged crest dividing the drainages of the New and Trinity rivers. They occur in small numbers at elevations from 5,500 to 6,200 feet on outcroppings of granite. Being sun-lovers and wanting a variety of vegetation for food, they avoid the dark forest of virgin Douglas-fir (*Pseudotsuga taxifolia*) and white fir (*Abies concolor*) which clothe the slopes of the mountain.

In 1949 when logging operations were first started in the virgin timber, these squirrels were not expected to be present to hinder reforestation, as they do in the Sierra Nevada by eating coniferous seeds. Two and a half miles of continuous forest separated their na-

tural habitat from the site of tree-cutting, which was a thousand feet lower in elevation. Then in June of 1953, Mr. Robley Broderick of the United States Forest Service saw golden-mantled squirrels on logged land.

Indians, who every spring follow the ancient practice of driving cattle from the lowlands of Hoopa Valley to Trinity Summit, stated that heretofore the squirrels had lived only on the crest of the mountain; and Mr. Robert Talmadge, a naturalist who is thoroughly familiar with the wildlife of the region, said that he had never recorded them below the Trinity-New River Divide. In the previous year, I had trapped chipmunks in some of the ten-acre cut-overs without finding evidence of golden-mantled squirrels. But when I explored the same area in 1953, squirrels were to be seen on all logged land to the lower limit of white fir. The only cut-overs they had not invaded were ones in the tan oak (*Lithocarpus densiflorus*) belt below 4,000 feet.

By 1954, in spite of poison (Compound 1080) that the Forest Service had distributed on wheat baits during the preceding November in an unsuccessful attempt to protect coniferous seed from rodents, the squirrel population had increased appreciably. Numbers per acre appeared to be greater than on the ridge from which the original stock had emigrated. On July 8, thirty-three traps set at forty-foot intervals caught eleven adults. Females were in the lactating stage of the reproductive cycle, but young animals had not yet appeared above ground.

The explanation for the presence of the rodents seemed to be that sometime between 1949 and 1953, a few squirrels moved downhill from their homes on the Trinity-New River Divide, which could support only a thin population of animals, traveled through dense forest inimical to the species, and, upon reaching logged land, established themselves and multiplied. They could not have followed roads, for the region was a virgin wilderness penetrated only by a few man-made trails.

There is little likelihood that the activities of lumbermen a number of miles from the ridge had brought about a deliberate migration of squirrels. More probably, for centuries young individuals had dispersed into the forest every year from parental dens on the granite and, not finding suitable habitats, had died. The few meadows in the woods were not large enough to support them. But when emigrants wandered onto newly logged land that was exposed to sunlight and where, in contrast to the virgin forest, a variety of herbaceous and brushy vegetation was growing, they had come into a habitat that was highly favorable.

As a result, golden-mantled squirrels must now be included among those small mammals that, because of seed-eating habits, are a threat to reforestation of the Douglas-fir–white fir belt. Their presence is one of the many drastic changes that logging has inflicted on the environment, which make reforestation, whether by artificial or natural means, a difficult task. At the present time, the cut-overs are inadequately stocked with coniferous seedlings. The forest, which for ages had reproduced itself successfully under conditions precluding squirrels, is now being replaced by brush.—Lloyd Tevis, Jr., *Department of Zoology, University of California, Davis.* *Received July 10, 1955.*

TYPE LOCALITY OF THE MOGOLLON RED SQUIRREL, *TAMIASCIURUS HUDSONICUS MOGOLLONENSIS*

A large part of east-central Arizona is unsuitable for red squirrels. Between the Painted Desert on the north and the Mogollon Rim to the south there is an almost unbroken forest of ponderosa pine, *Pinus ponderosa* Lawson, stretching in a broad band for one hundred and fifty miles along the top of the Mogollon Mesa from the White Mountains on the east to the San Francisco Peaks to the west and north. Among the pines between these two ranges are some widely scattered small groups of Douglas fir, *Pseudotsuga taxifolia* (Poir.) Britton, with white fir, *Abies concolor* (Gordon & Glendinning) Hoopes, and Engelmann spruce, *Picea Engelmanni* Parry, in a few places. It was only in firs or spruces that we found red squirrels in this region, and this agrees with Mearns' comments (1907) that

he never saw these squirrels in the pines, and with Bailey's (1931) observations that they prefer the smaller spruce and fir cones for food. Where we found some Douglas fir trees, we were able to collect *Tamiasciurus* at three places: West of Springerville on the lower slopes of the White Mountains; near Promontory Butte; and just south of Mormon Lake. Red squirrels were plentiful in the spruce-fir forest of the San Francisco Peaks. They were also noted in the few Douglas fir trees about Kehl Spring Forest Camp near Baker's Butte, and at Big Lake Forest Camp in the White Mountains.

Because of the widely discontinuous distribution of red squirrels in this area, it has been of interest to try to definitely locate "Quaking Asp Settlement, summit of Mogollon Mountains," the type locality of the Mogollon Red Squirrel, *Tamiasciurus hudsonicus mogollonensis* (Mearns), which was collected on May 25, 1887, by Dr. Edgar Mearns. While collecting Arizona mammals during the summer of 1952, an attempt was made in the field to find this settlement. It could not be found, and since that time a search has been made to try to locate its former site. So far as we have been able to determine, Quaking Asp Settlement does not appear on any map of Arizona, historical or recent.

The so-called Mogollon Mountains have been variously placed in Arizona by different authors. Mearns (1890*a*, map on p. 4) shows them as lying roughly northeast of Baker's Butte (an elevation about fifty miles to the south of Flagstaff), while Merriam (1890, map 1) places them to the east of Baker's Butte. Bailey (1931) states that Mearns' Mogollon Mountains, or Mogollon Mesa, are the western part of the White Mountains, (which lie about one hundred miles to the east and south of Baker's Butte). More recently Miller and Kellogg (1955) say that the summit of these mountains is near Stoneman Lake and Mormon Lake (about twenty-five and thirty miles respectively to the north and a little to the west of Baker's Butte). This variance may have arisen through a lack of understanding of the real topography of the region. What in the past have been called the Mogollon Mountains in Arizona (not to be confused with the separate Mogollon Mountains in Catron County, New Mexico) are not a distinct mountain range, but form the southwestern portion of the uplifted Colorado Plateau, which is named the Mogollon Mesa on modern maps. Its southern edge, 6,000 to 8,000 feet above sea level, is sharply defined by an escarpment called the Mogollon Rim. Two major elevations of this part of the plateau are the White Mountains and the San Francisco Peaks, while Baker's Butte, Mahan Mountain, and Hutch Mountain (the last two twenty-five miles southeast of Flagstaff) are minor features.

Although Quaking Asp Settlement has disappeared, it has been possible to locate Mehren's Ranch, which Mearns (1890*b*) said was a part of Quaking Asp Settlement. In a letter Mr. Dave Wingfield of Camp Verde, Arizona, contributes the information that Mehren had two ranches, one at Montezuma Well in the Verde Valley at 3,600 feet, and the other up on the Mogollon Mesa at Horse Shoe Spring on the side of Mahan Mountain at 7,000 feet, which is about ten miles east of Stoneman Lake. This last location agrees with Mearns' dairy (unpublished) in which he wrote that on the 24th of May, 1887, he camped at Stoneman Lake, and the next day (the day the type was collected) rode ten miles to Mehren's Ranch, where he says (1907) that he could watch red squirrels while camped in a deep notch between two mountains (these would be Hutch and Mahan). Therefore, it can now be stated that Quaking Asp Settlement, the type locality of *Tamiasciurus hudsonicus mogollonensis* (Mearns), was located on the northerly side of Mahan Mountain, Coconino County, Arizona, approximately 34° 46′ N, 111° 23′ W, near the presently named Quaking Aspen Canyon and about twenty-five miles south of Flagstaff.

The final determination of the former location of Quaking Asp Settlement would not have been possible without the help of the following: Dr. Remington Kellogg and Dr. Charles O. Handley, Jr., of the U. S. National Museum, Washington, D. C.; Dr. Walter S. Phillips and Dr. Charles T. Mason, Jr., of the University of Arizona, Tucson, Arizona; Katharine Bartlett, Museum of Northern Arizona; and K. A. Keeney, Forest Supervisor, Coconino National Forest, Flagstaff, Arizona. Acknowledgment is also made to the Arizona Game and Fish Commission for permission to collect scientific specimens in Arizona.

LITERATURE CITED

BAILEY, V. 1931. Mammals of New Mexico. North Amer. Fauna No. 53. 412 p.

MEARNS, E. A. 1890*a*. Ancient dwellings of the Rio Verde Valley. Pop. Sci. Monthly, 37: 745–763.

———. 1890*b*. Observations on the avifauna of portions of Arizona. Auk, 7: 45–55, 251–264.

———. 1907. Mammals of the Mexican boundary of the United States. Part I. U. S. Nat. Mus., Bul. 56. 530 p.

MERRIAM, C. H. 1890. Results of a biological survey of the San Francisco Mountain region and desert of the Little Colorado, Arizona. Parts 1–4. North Amer. Fauna No. 3. 101 p.

MILLER, G. S. AND R. KELLOGG. 1955. List of North American Recent mammals. U. S. Nat. Mus., Bul. 205. 954 p.

FRANCES L. BURNETT AND ROBERT W. DICKERMAN, *Museum of Comparative Zoology at Harvard College, Cambridge 38, Massachusetts, and Arizona Cooperative Wildlife Unit, University of Arizona, Tucson, Arizona.* *Received May 30, 1955.*

NOTES ON A POPULATION OF EASTERN FLYING SQUIRRELS

The following notes were collected during the period, February 22 to March 19, 1954, in conjunction with a population study of fox squirrels (*Sciurus niger rufiventer*) in a 31-acre, black oak-hickory woodland in Mason County, Illinois. The area was bordered on three sides by large, cultivated fields and on the fourth side by a highway that separated the area from an adjacent woodland. It was thought that there was little or no interchange of flying squirrels (*Glaucomys v. volans*) between the two areas during the period covered by the study. A good tracking snow that fell in early March revealed that during a three-day period squirrels had not crossed the highway separating the two woodlands.

Forty-five live traps designed for taking fox squirrels were placed in selected locations throughout the area. The density of traps was not less than one per acre. These were operated in three trapping periods for fox squirrels. Flying squirrels were free to enter the baited traps, which were left in the set position overnight.

Forty-nine flying squirrels were taken in 13 nights of trapping. Six of these squirrels had succumbed in the traps. The remaining 43 squirrels were either sacrificed upon removal from the traps or were released in woodlands several miles from the point of capture. No effort was made to trap the area to extirpation, although trapping success for the last period was considerably lower than that for each of the preceding periods. Twenty-three squirrels were captured February 22–26; 17 were captured March 1–5; and 9 were taken March 16–19. The minimum population of flying squirrels therefore averaged about 1.6 animals per acre. Burt (Misc. Pub. Mus. Zool. Univ. Mich., No. 45: 1–58, 1940) found that the population of this species ranged from 1.6 to 1.34 animals per acre in an area of 3.72 acres, and Jordan (Jour. Mamm., 29: 44–48, 1948) found an average of 1.1 flying squirrels per acre in a woodland of 28 acres. Both of these studies were made in midsummer before the appearance of the second litters of the year. Sollberger (Jour. Mamm., 24: 163–173, 1943) removed an average of 2.2 and nearly 5 flying squirrels per acre from areas of about 10 and 3.8 acres, respectively. Neither area was trapped to extirpation. The dates of these removals were not indicated.

Sex was determined in 48 of the squirrels trapped in the present study. The ratio of males to females was 1:2 (16 males:32 females). It is worthy of note that in the initial period of trapping, 20 of the 22 squirrels captured and examined were females. The preponderance of females in the traps indicated that there was a sex-related difference in the activity of flying squirrels at that time of the year. This may have been related either to a dispersal of females from the usual winter concentrations of these animals following breeding, or to an increased demand for food as a result of pregnancy.

The age of most females was not determined. Examination of 16 males revealed that 14 were sexually mature; both the testes and Cowper's glands were much enlarged, and the

individuals were assumed to be in breeding condition. This would suggest that flying squirrels that are born during summer are capable of breeding in the first winter following birth.

Six females trapped during the first week of March were sacrificed for determination of pregnancy. All were found to contain embryos. One female contained 2 embryos, three contained 3, one contained 4, and one female contained 5 embryos. The stage of development of the embryos varied from 3 mm. nodules to 18 mm.

Body weights of 47 individuals were recorded. Because of the presence of developing embryos, females were generally heavier than males. The weights of 31 females ranged from 0.13–0.22 pound; the weight recorded with greatest frequency was 0.17 pound, and the average was also 0.17 pound. The body weights of 16 males ranged from 0.12–0.16 pound; the weight of greatest frequency was 0.14 pound, and the average was 0.14 pound.—James S. Jordan, *Illinois Natural History Survey, Urbana, Illinois.* *Received May 13, 1955.*

REPRODUCTION IN THE EASTERN FLYING SQUIRREL IN WEST VIRGINIA

Inspections of 114 gray squirrel den boxes on Seneca State Forest. Pocahontas County, West Virginia provided some interesting data pertaining to the reproductive ability of the eastern flying squirrel, *Glaucomys volans volans* (Linnaeus). Thirty-nine litters were found in the summer and late fall of 1953 and the springs of 1954 and 1955. In addition twenty-four pregnant females were trapped.

Table 1.—*Embryo counts and litter sizes of 63 flying squirrels in West Virginia, 1953–55*

Date	Size of litter						Total litters	Total young	Ave.
	1	2	3	4	5	6			
Litters: June 1–5, 1953	2	10	3	1	0	1	17	41	2.41
Litters: Nov. 13–20, 1953	2	2	3	0	3	2	12	42	3.50
1953 Total	4	12	6	1	3	3	29	83	2.86
Embryos: Feb. 13–Mar. 26, 1954	0	1	4	9	4	1	19	76	4.00
Litters: Apr. 1–May 1, 1954	1	2	1	3	2	1	10	36	3.60
1954 Total	1	3	5	12	6	2	29	112	3.86
Embryos: Feb. 22–Mar. 15, 1955	0	1	1	2	0	1	5	19	3.80
Grand Total	5	16	12	15	9	6	63	214	3.40

Litters found in 1953 were one-half to three-fourths grown. Observations of pregnant females and lactating females in the spring of 1954 indicated that the peak of the parturition period occurred during the last week in March and the first week in April. Comparison between embryo counts and litter counts in 1954 also revealed a 10 per cent decrease, 4.00 to 3.60 young. (Table 1). The grand average of the 63 embryo and litter counts was 3.40.—Hans G. Uhlig, *Seneca State Forest, Dunmore, West Virginia.* *Received June 12, 1955.*

DENTAL FORMULA IN THE MUROIDEA

Several students of mammals seem favorably inclined toward the theory that in certain rodent groups the tooth usually identified as the first molar is in reality a deciduous premolar, the permanent premolar that normally replaces it being suppressed. Others state or

imply that it is the permanent premolar that is represented, and still others do not make themselves clear as to whether the theory applies only to some or to all rodents. In any case, advocates of these theories think that the rear cheek-teeth are not the third molars but the second, and agree in applying these theories to the muroids. Recent statements in the Journal of Mammalogy more or less favoring the premolar theory have been made by D. H. Johnson (33, 70–72, 1952) and E. M. Hooper (36, 298–299, 1955). Hooper refers to the idea as an hypothesis, but Johnson suggests that it is mostly the inconvenience of a changed terminology that has prevented its acceptance.

C. I. Forsyth Major, who originated the deciduous premolar theory, was influenced in arriving at this theory by reason of his belief that in the evolution of the rodent dentition the trend was always toward simplification and never toward increased complexity of crown. M. A. C. Hinton was led also, because of this same belief, to consider favorably at times, the premolar theory (MONOGRAPH OF THE VOLES AND LEMMINGS, LIVING AND EXTINCT: 124–125, 1926). It does not follow, of course, that the deciduous premolar theory is false if this particular theory is false—which I think it is—but perhaps the reasons behind its development should be held in mind by those presently advocating it. It certainly is not amiss to defend the dental formula now used.

Although no absolute proof exists as to the validity of either theory, it seems to me that the burden of proof falls on the advocates of the premolar theory because the teeth concerned are now clearly monophyodont. Molar loss is a somewhat improbable event to occur in rodents on theoretical grounds. Only a scattering of mammals which use their rear teeth for grinding or crushing have lost any of them (compare for example all ungulates). With contrasting functions of grinding and gnawing a diastema develops, and this is accompanied by loss of teeth between the anterior teeth involved in gnawing and the posterior grinders. One would expect reduction of premolars rather than the terminal molars. That this loss is improbable rather than impossible is of course conclusively shown by the fact that in the Hydromyinae among rodents the third molars are lost or vestigial; loss sometimes is to be noted in *Mus musculus*; and molar loss under somewhat peculiar circumstances is seen also in the extinct rodent family Mylagaulidae. Although the loss in the Muridae has been cited as making more probable the premolar theory, it perhaps is the result of some special circumstance rather than a continuation of a general trend in molar reduction beginning in the Eocene. In any case, as evidence for the premolar theory, this loss is more or less balanced by the condition in the dormice mentioned below. Also cited as evidence for this theory is the occasional presence of extra molars in the jaws of muroid rodents. I think, however, the usually accepted theory that the cheek-teeth of muroids represent only true molars is sustained by several lines of argument enumerated below.

(1) If dental anomalies in which extra molars are present are indicative of reduction of posterior molars, then these kinds ought to be of increasing frequency in the older geologic record. This is not so. For example, cricetids are known by hundreds of mid-Oligocene specimens, and yet so far as I know, not one case of such an anomaly has come to light. The muroid formula is known to occur as far back in time as late Eocene. This suggests to me that so much time has elapsed since reduction that one would hardly expect evidence of this reduction persisting into Recent time. It would seem also that if extra molars in Recent specimens represent phylogenetically lost molars, then we might expect to find in some fossils additional teeth representing premolars that have certainly been so lost. No fossil rodent shows these.

(2) Extra molars are known to occur in kinds of mammals other than rodents and in which almost certainly no interpretation as phylogenetically lost molars is possible. *Otocyon* usually has four molars (four lower molars normally present, four upper molars frequently present). Our native coyotes (*Canis latrans*) have four lower molars exceptionally. Does this mean that the Family Canidae generally has lost a fourth molar which even the earliest and most primitive placentals lack, although some of their number have retained a condition lost in the ancestry of placentals prior to the Late Cretaceous? Supernumerary "third molars" are known to occur occasionally in primates. An occasional domestic horse

also has extra molariform teeth, and we really do know the history of cheek-teeth of horses. It seems to me that consistency demands that we interpret the extra teeth in rodents, in the absence of evidence to the contrary, in the same way as the examples cited in other orders. I doubt if this should be as phylogenetically lost teeth.

(3) If the fossil record of the muroids could be traced back far enough the matter would be settled. This unfortunately we can not do. Obviously, the species transitional from generalized rodents would be pre-Oligocene, and the earliest rodents of record are late Paleocene. We have reason then to think that the muroid group evolved in the Eocene. Of all Eocene rodents the sciuravines offer the best possibility of being muroid ancestors. If these are not, then we know of none that are. Among sciuravines there are several that show quite reduced fourth premolars (*Pauromys*, *Sciuravus*? *rarus* as examples). Perhaps it is significant that all known Eocene rodents have large third molars—frequently more robust than any other cheek-teeth. Among Recent rodents, dormice (Gliroidea) have been cited as primitive myomorphs. Dormice have premolars smaller than the third molars, and the former are sometimes much reduced. The last molars are not especially reduced in any known member of this group. Several students (Matthew, Wilson, Wood) of Eocene rodents have proposed that the paramyine group is ancestral to all rodents. Whatever the facts are in respect to this particular theory, these rodents are the oldest known, and have the large third molars one would expect on theoretical grounds in a grinding dentition.

(4) Lastly, I think it is well to hold in mind the technical definition of a molar. One may make too much of the distinction between the molars and the deciduous dentition. Many modern authorities hold that the permanent dentition consists of two quite different categories: (a) the incisors, canines, and premolars that together constitute a genuine second set of teeth, and (b) the molars that are part of the deciduous set but with delayed eruption. It would thus follow that those molars that even the advocates of the premolar theory would accept as truly such can be described technically in the same way as the anterior cheek-teeth under the deciduous premolar theory—that is, as deciduous teeth in which the permanent replacements are suppressed (in the early phylogenetic history of mammals, before they were technically mammals, all parts of their dentitions were replaced an indefinite number of times). The premolar theory is almost meaningless in the absence of actual historical evidence for muroids that the anterior cheek-teeth are homologous with the deciduous premolars of primitive placentals.—ROBERT W. WILSON, *Museum of Natural History, University of Kansas, Lawrence, Kansas.* *Received July 11, 1955.*

SOME FOOD PREFERENCES IN FIELD MICE

In the course of rearing field mice (*Microtus pennsylvanicus*) in the laboratory, an experiment was set up to determine preferences for different kinds of cereal grains. The cereals used were wheat, oats, barley and cracked corn; pumpkin seeds also were made available in some of the tests.

A male and a female field mouse, aged five months and kept in the same pen, were provided with four glass containers that were filled with different cereal grains. During the first two weeks, a decided preference was shown for corn and wheat over oats and barley regardless of the sequence of the feeding dishes. In the third week, only barley and oats were provided. Neither of these was eaten readily, and no preference was evident. Wheat and corn were provided during the fourth week, and some preference was shown for wheat over corn. In the fifth week, corn and pumpkin seeds were made available; the corn was eaten, but the pumpkin seeds were left. A final test series in the fifth week consisted of barley, wheat, corn, and pumpkin seeds. The wheat was preferred to corn, while the barley and pumpkin seeds were scarcely touched at all.

The order of preference for the above foods in the diet of field mice was concluded to be wheat, corn, oats and barley, and pumpkin seeds. An additional dietary item for which the field mice showed great fondness was living white grubs. The grubs were consumed in large numbers in strong preference to all other foods provided during this experiment. It is suggested that this fondness for June beetle larvae may indicate economic importance

of field mice in the natural control of the June beetle.—A. A. WELLWOOD, *Department of Botany, Ontario Agricultural College, Guelph. Received May 23, 1955.*

ALBINO *MICROTUS* REARED IN THE LABORATORY

In June, 1954, a litter of five meadow voles, *Microtus pennsylvanicus pennsylvanicus* (Ord.), was discovered containing one albino. All the voles were furred and had the eyes open. On the basis of published studies on the biology of the vole, this litter was estimated to be ten to fourteen days old when found.

During the first day in the laboratory the young voles moved about feebly, but later became quite active. The albino, a female, was the smallest of the litter, but was more active than most of her litter mates. Within a few days after being brought into the laboratory, three of the normally pigmented voles died. The albino and a normally pigmented male have survived, and are now apparently healthy and vigorous adults. The albino is still slightly smaller than her litter mate, but appears to be a well-developed female vole.

The two voles were reared together in a large terrarium. Their diet in the first week of captivity consisted of diluted canned milk, lettuce and fox cubes. Subsequently they have been provided with a variety of foods including fox cubes, wheat kernels, oats, barley, cracked corn, pumpkin seeds, sprouted wheat, lettuce, carrots, fresh grass turf and clover. In addition, they have shown a great fondness for June beetle larvae.

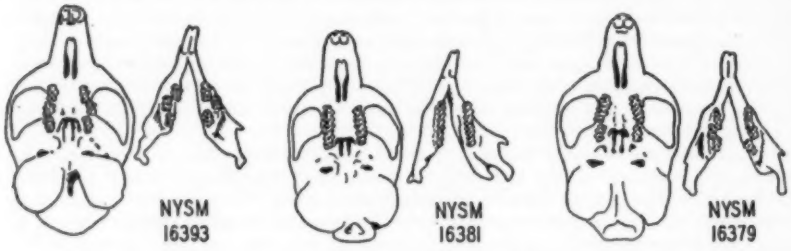
At the age of about three months (September 8, 1954) the albino and her male litter mate weighed 26.4 grams and 26.9 grams respectively. On May 13, 1955, their weights were 46.6 grams and 57.1 grams respectively. An unrelated "normal" male vole, full-grown when live-trapped, weighed 63.2 grams after being kept in the laboratory for a year.

Although reared together and evidently in a healthy physical condition, these two voles have not produced any young. To stimulate mating, a day length of fifteen hours with somewhat subdued light has been maintained for a continuous period of eight weeks. During this interval an additional unrelated male vole was kept with the other two animals to offset the possibility that the male litter-mate might be sterile. Despite attention to diet and photoperiod, there is as yet no indication that successful mating has occurred.

Owen and Shackelford (Jour. Mamm., 23:306–314, 1942) have summarized earlier records of the occurrence of albino *Microtus*. To the best of our knowledge, the present note is the first record of the successful rearing of an albino *Microtus* to maturity.—E. I. SILLMAN AND A. A. WELLWOOD, *Department of Entomology and Zoology, and Department of Botany, Ontario Agricultural College, Guelph, Canada. Received May 23, 1955.*

MALARRANGEMENT OF TEETH IN *CLETHRIONOMYS GAPPERI*

During the summer of 1952 Mr. James L. Chamberlain collected mammals for the New York State Museum in the Catskill Mountains of New York. When the skulls were removed from the dermestid colony one skull showed the grinding teeth arranged in a distinct zigzag pattern in the lower jaws with matching teeth of the upper jaw correspondingly disarranged. A second specimen with the same dental malarrangement was found in this collection. The teeth of both were in excellent occlusion and chewing was little impaired,



as both were fully adult males apparently in good condition. The illustration (Fig. 1), redrawn from a photograph, shows both skulls, with that of a more normally dentitioned specimen in the center. New York State Museum No. 16393 was taken in N. Y., Greene Co., 3 miles SSE Hunter at 2050' alt. on July 29th; No. 16381 (normal dentition ♀ ad.) was taken in N. Y., Greene Co., 3.5 miles SSE Hunter, Notch Lake, on July 15th; and No. 16379 was taken at the same place on July 14th. Out of 32 specimens of this species taken in the same area, teeth of five adults (3♂, 2♀) showed some evidence of 'staggering' but not to the degree as illustrated. It is likely that this malarrangement has a genetic basis.—E. M. REILLY, JR., *New York State Museum, Albany, New York. Received June 3, 1955.*

AQUATIC TENDENCIES IN THE JUMPING MOUSE

Notes on the swimming ability of the jumping mouse are recorded by Preble (Jour. Mamm., 25: 200–201, 1944) and Jones (Jour. Mamm., 31: 453–454, 1950). Further to these notes, the writer feels that the following observations might be of interest:

In September 1953, while camping by a small river in northern Manitoba, my attention was attracted by continued splashing sounds at the border of the stream. Investigation with a flashlight showed a jumping mouse, *Zapus hudsonius* sp., swimming from tussock to tussock in a quiet backwater. The mouse showed no alarm at the light and continued its journeys from one small island to another for half an hour, with frequent returns to shore. In this instance, the mouse swam on the surface of the water at all times. Similar activities of presumably the same mouse were observed on the following evening, with the mouse showing no alarm and returning to shore at the writer's feet.

On May 7, 1955, the writer flushed a jumping mouse, *Zapus h. campestris*, from the bank of a creek near Winnipeg, Manitoba. The mouse leaped into the water and immediately submerged, swimming rapidly approximately 18 inches below the surface. The animal swam submerged for about thirty seconds at a time, alternately surfacing (for an instant) and diving for about three minutes, after which it came towards shore and crouched in the shallows under some reeds where it was captured. As far as could be seen, swimming, which was extremely rapid, was accomplished by using the hind feet only, working them together in frog fashion. At this writing the mouse, a male, is thriving in captivity.—R. W. SUTTON, *The Manitoba Museum, Winnipeg. Received June 9, 1955.*

NOTE ON THE DISTRIBUTION OF THE INDIAN CRESTED PORCUPINE *HYSTRIX INDICA*

Ellerman and Morrison-Scott (CHECKLIST OF PALAEARCTIC AND INDIAN MAMMALS, 1758–1946. 1951) list the approximate distribution of *Hystrix indica* as "Ceylon, Peninsular India, northwards to Rajputana, Sind, Punjab, Kashmir, Nepal, Baluchistan; Persia, Iraq, Palestine, Syria, Asia Minor, Southern Arabia, Southern and Eastern Russian Turkestan (north to Kara Kum, Tashkent Oasis, Kirghiz Range and Trans-Ili Alatau), and Trans-Caucasia if *hirsutirostris* is the same."

While serving as an archaeologist on the Second Afghan Expedition of the American Museum of Natural History, New York, New York in 1950–51, I killed and photographed a porcupine that had been stealing grain from a Pathan farming village in Kandahar Province, Afghanistan. I sent a copy of the photograph to Ellerman and Morrison-Scott and received the following answer:

"Re your letter 13 February, 1955: the specimen is the Indian Crested Porcupine. The reason for not mentioning Afghanistan in the Checklist is simply that we had no record of a specimen. But the distribution is labelled as approximate and it could be deduced that if the animal occurred in surrounding countries it also occurred in the centre. You have now produced the proof, for which many thanks. Yours faithfully, T. C. S. Morrison-Scott (for J. R. Ellerman, absent)."

Dr. George C. Goodwin, Department of Mammalogy, American Museum of Natural History, examined the animal bone excavated by me from the cave of Shamshir Ghar, 15 miles east-northeast of Kandahar city in Afghanistan. He has identified *Hystrix* fragments

from the Early Islamic (867–1222 A.D.) levels; species not discernible.—Louis Dupree, *Research Studies Institute, Arctic-Desert-Tropic Information Center, Air University, Maxwell Air Force Base, Alabama. Received April 30, 1955.*

COPROPHAGY IN THE COTTONTAIL

Coprophagy in the swamp rabbit (*Sylvilagus palustris paludicola*) as noted by Hamilton (Jour. Mamm., 36: 303, 1955) confirms the suspicion of Watson and Taylor (Science, 121: 314, Feb. 25, 1955) that some of the North American Lagomorpha would be found to indulge in the habit of reingesting their own fecal pellets. The present note, encouraged by Dr. W. J. Hamilton, Jr., lends weight to his assumption that "coprophagy is common to many North American lagomorphs."

In February and March, 1950, and again in the winter of 1951, I was accustomed to seeing a cottontail (*Sylvilagus floridanus mearnsi*) just outside my office window almost daily for several weeks. The rabbit habitually bedded on the same spot both years (suggesting that it was the same individual), backed against the stems of a small, deciduous shrub. The earth beneath the shrub was devoid of leaves, grass, or any other cover, and no twigs interrupted a clear view of the animal 20 feet from my desk. As the office is on a level with the ground outside, every motion of the rabbit could be seen merely by turning my head. It seemed oblivious to persons standing at the window about five feet closer to its position although it faced the window and away from the sidewalk about ten feet behind. Human traffic and dogs using the sidewalk seemed not to concern the cottontail at all; but dogs occasionally wandered through the shrubbery and flushed the rabbit, resulting in spirited chases. The animal was usually absent for a few days after such disturbance.

When not "freezing" or tensed for flight, the cottontail was anything but quiet; but its actions seemed to indicate an air of ease and confidence as it mouthed the fur, directed the ears first one way and another for sounds, stood full length to look about, scratched itself, and chewed as on a cud.

Coprophagy was observed when the rabbit lifted its left foreleg and turned its head sideways and downward to reach beneath its belly. At the same time the body was raised somewhat from the ground on the haunches, the anus was brought forward, and as a pellet appeared it was taken into the mouth and eaten before it touched the ground. No more than two or three pellets were seen taken at any one time. Chewing occurred both before and after the pellets were ingested so it was not clear whether the pellets were being chewed or not.—Charles M. Kirkpatrick, *Purdue University Agricultural Experiment Station, Lafayette, Indiana. Received July 30, 1955.*

LATE BREEDING IN MOOSE, *ALCES ALCES*

Young moose are usually born during the latter part of May or early June. Although some records of early breeding may be found in the literature, it does not seem possible to find a late breeding record like this one, reported by a Quebec sportsman. On August 14, 1954, while trout fishing in the Laurentides Provincial Park about 75 miles north of Quebec City, Mr. Gerard Guay heard his two guides talking about a pregnant cow moose they had seen the previous day on that same lake. Mr. Guay was very sceptical and the guides were still trying to convince him of the veracity of their story when the same moose appeared, but this time accompanied by a calf that could not be more than a few hours old. The gestation period being considered to be about eight months, the mating would have occurred about December 15, 1953, which seems rather unusual and worth reporting. Both guides, Lorenzo Fortin and Angello Bouchard, who spent their lifetime in this area had never encountered such a case.—Gaston Moisan, *Fish & Game Department, Quebec, P.Q. Received July 22, 1955.*

REVIEWS

Storer, Tracy I. and Lloyd P. Tevis, Jr. CALIFORNIA GRIZZLY. Univ. California Press, Berkeley. 335 p., 36 fig. (halftones), 2 color pl., maps. 1955. Price, $7.50.

This book is a fitting memorial to the vanished glory of California's most magnificent mammal. The last grizzly bear is thought to have been killed in California in 1922. There is a record of one having been seen in 1924, but since then no more valid records have appeared. The complete extirpation of a mammal once so abundant in as large a state as California is a modern tragedy. This book traces the history of the bear from the coming of the white man to the last lonely canine tooth that was delivered to a museum for identification.

The complex taxonomic history of our native bears is traced in an introductory chapter. This is followed by chapters on records of grizzlies in California, physical characteristics, and habits.

The relations between the bears and Indians and the Spaniards are traced from the historical records, with numerous quotations from vivid first-hand accounts of encounters between the Spaniards and the bears. The history of the so-called sport of bear-and-bull fights is recounted from their inception by the Spanish to their adoption and final termination at the hands of American settlers. Local ordinances and scarcity of bears ended the carnage about 1850.

The conflicts between grizzlies and American settlers are recounted in a separate chapter, followed by a fascinating review of methods of hunting, with many tales of first-hand encounters. While these spotlighted events make thrilling reading, it is obvious that the grizzly never had a chance against the arrayed forces of traps, poisons and guns.

There is a chapter on the famous Grizzly Adams, a forty-niner from New England who made a profession of hunting, trapping, taming, and exhibiting the bears.

Closing chapters discuss famous captive grizzlies, grizzly lore, and the California grizzly as an emblem of the state. The reaction of this reader to this last was, that rather than seeking borrowed glory from the vanished grizzly, the state should hang its official head with shame. Surely a state with as much wild mountainous area as California could have established a token refuge for the remnants of this once large population of bears.

The book closes with appendices: known museum specimens, last records, Indian names, and sources. An extensive bibliography and an index are provided.

Illustrations are an important feature of the book from the colored frontispiece reproduction of a painting, *Return from a Bear Hunt*, to the reproductions of contemporary drawings, and the photographs of bears, habitats, and skeletal anatomy.

The authors have been thorough and the book makes fascinating reading.—W. ROBERT EADIE.

Wood, Casey A. and F. Marjorie Fyfe (Translators and editors). THE ART OF FALCONRY BY EMPEROR FREDERICK II. Charles T. Branford Co., Boston, Massachusetts. (Reprinted from Stanford University Press Edition of 1943.) 637 p., 186 pl. (2 color). 1955. Price, $20.00.

This edition of the original publication by the Stanford University Press makes this handsome volume again available. The Stanford printing was a limited one of 750 copies.

While the work contains little of direct interest to mammalogists as such, any zoologist will find it revealing and fascinating to read of the state of knowledge in biological subjects in the year 1250 as exemplified by this work of Emperor Frederick II. Those mammalogists who are also falconers will certainly covet this book.

The book contains an extensive annotated bibliography of falconry, both ancient and modern, a glossary of falconry terms, and an index.

The illustrations include facsimile reproductions of old prints as well as photographs

of relics, falcons, and historical sites. A full color portrait of the Emperor graces the frontispiece.—W. Robert Eadie.

Bonner, John Tyler. Cells and Societies. Princeton University Press, 234 p., 46 figs., 8 plates, 1955. Price $4.50.

The purpose of this book is by no means apparent. It gives a hasty survey of some social aspects of animals in reference to three functions: nourishment, reproduction and coordination. The mammalogist will learn nothing about mammals and probably little about other animals. The information is not up to date although a bibliography lists a few recent papers that are ignored in the text. Perhaps this is a "popular" book. If so more than five pages could profitably have been devoted to comparing human with other animal societies.—David E. Davis, *School of Hygiene and Public Health, Johns Hopkins University, Baltimore 5, Maryland.*

RECENT LITERATURE

(Conducted by David H. Johnson, Claude W. Hibbard, Charles P. Lyman, Richard H. Manville, and Henry W. Setzer)

[Reprints of this section may be purchased from the Corresponding Secretary]

Abe, Yoshio. Digital abnormalities in a cat. Jour. Sci. Hiroshima Univ., Ser. B, vol. 15, div. 1, pp. 189–191, illus. December, 1954.

Allen, Ross, and Wilfred T. Neill. The striped skunk. Florida Wildlife, Tallahassee, vol. 9, no. 4, pp. 6, 42, illus. September, 1955.

Appelman, F. J. Über *Sus celebensis* Müller und Schlegel. Zool. Garten, Leipzig, n.f., vol. 21, no. 3, pp. 152–156, illus. 1955.

Arden, G. B., and K. Tansley. The spectral sensitivity of the pure-cone retina of the grey squirrel (Sciurus carolinensis leucotis). Jour. Physiol., London, vol. 127, no. 3, pp. 592–602. March, 1955.

Ashley, G. T. Supra-sternal ossicles in primates other than man: some isolated cases in gorilla and chimpanzee. Nature, London, vol. 176, no. 4482, pp. 608–609, illus. September 24, 1955.

Ashton, E. H., and A. P. D. Thomson. Some characters of the skulls and skins of the European polecat, the Asiatic polecat and the domestic ferret. Proc. Zool. Soc. London, vol. 125, pt. 2, pp. 317–333. August 31, 1955.

Attenborough, David. Animal collecting in British Guiana. Illus. London News, vol. 137, no. 3568, pp. 421–424, illus. September 10, 1955. (Capybara, anteater, tree porcupine, sloth, manatee)

Averill, R. L. W., C. E. Adams, and L. E. A. Rowson. Transfer of mammalian ova between species. Nature, London, vol. 176, no. 4473, pp. 167–168. July 23, 1955.

Bader, Robert S. Variability and evolutionary rate in the oreodonts. Evolution, Lancaster, vol. 9, no. 2, pp. 119–140, illus. June, 1955.

Barto, Elizabeth. Boggler, an inherited abnormality of the deermouse (*Peromyscus maniculatus*), characterized by a tremor and a staggering gait. Contrib. Lab. Vert. Biol. Univ. Michigan, Ann Arbor, no. 71, pp. 26. August, 1955.

Becker, Kurt. Über Art- und Geschlechtsunterschiede am Becken einheimischer Spitzmäuse (*Soricidae*). Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 78–88, illus. August 3, 1955.

Berquist, Harry. "Tanumsvalen"—en grönlandsval. Fauna och Flora, pts. 4–5, pp. 139–144. 1955. (In Swedish, with German summary)

Bigalke, R. A bushveld tragedy. African Wildlife, Johannesburg, vol. 9, no. 3, pp. 195–198, illus. September, 1955. (Lions, antelopes)

BOPP, PETER. Schwanzfunktionen bei Wirbeltieren. Ein Beitrag zur vergleichenden Biologie und Psychologie der Wirbeltiere. Rev. Suisse Zool., vol. 61, no. 3, pp. 83–151, illus. March, 1954.

BOWMAN, ROBERT I. Aerial reconnaissance of moose in summer. Jour. Wildlife Management, vol. 19, no. 3, pp. 382–387, illus. July, 1955.

BREATHNACH, A. S. The surface features of the brain of the humpback whale (Megaptera novaeangliae). Jour. Anatomy, Cambridge, England, vol. 89, pt. 3, pp. 343–354. July, 1954.

BROWN, S. G. Modern whaling in the Antarctic. Zoo Life, London, vol. 10, no. 2, pp. 35–40, illus. Summer, 1955.

BURTON, MAURICE. The maned wolf and other "dogs." Illus. London News, vol. 137, no. 3562, p. 194, illus. July 30, 1955.

BURTON, MAURICE. Further notes on rhinoceros. Illus. London News, vol. 137, no. 3566, p. 344, illus. August 27, 1955.

BURTON, MAURICE. "Protective colouring" in a genet. Illus. London News, vol. 137, no. 3567, p. 394, illus. September 3, 1955.

BURTON, MAURICE. Studying prairiedogs. Illus. London News, vol. 137, no. 3569, p. 490, illus. September 17, 1955.

BURTON, MAURICE. Foxes by day and night. Illus. London News, vol. 137, no. 3570, p. 532, illus. September 24, 1955.

CHEW, ROBERT M. The skin and respiratory water losses of *Peromyscus maniculatus sonoriensis*. Ecology, Durham, vol. 36, no. 3, pp. 463–467. July, 1955.

CHITTY, DENNIS. Allgemeine Gedankengänge über die Dichteschwankungen bei der Erdmaus (*Microtus agrestis*). Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 55–60. August 3, 1955.

CLARKE, J. R. Influence of numbers on reproduction and survival in two experimental vole populations. Proc. Royal Soc., London, ser. B, vol. 144, no. 914, pp. 68–85. August, 1955.

CLARKE, ROBERT. Sperm whaling from open boats in the Azores. Zoo Life, London, vol. 10, no. 2, pp. 47–55, illus. Summer, 1955.

COOKE, H. B. S. Some fossil mammals in the South African Museum collections. Ann. South African Mus., vol. 42, pt. 3, pp. 161–168, illus. January, 1955.

COWAN, I. MCT., AND A. J. WOOD. The growth rate of the black-tailed deer. Jour. Wildl. Management, vol. 19, no. 3, pp. 331–336. July, 1955.

CRANDALL, LEE S. Duck-billed platypus. Zoo Life, London, vol. 9, no. 2, pp. 73–76, illus. Summer, 1954.

CROWCROFT, PETER. Remarks on the pelage of the common shrew (*Sorex araneus* L.). Proc. Zool. Soc. London, vol. 125, pt. 2, pp. 309–315, illus. August 31, 1955.

DART, RAYMOND A. The first australopithecine fragment from the Makapansgat pebble culture stratum. Nature, London, vol. 176, no. 4473, pp. 170–171. July 23, 1955.

DASMANN, RAYMOND F., AND RICHARD D. TABER. A comparison of four deer census methods. California Fish & Game, vol. 41, no. 3, pp. 225–228. July, 1955.

DERANIYAGALA, P. E. P. Some extinct elephants, their relatives and the two living species. Ceylon Nat. Mus. Publ., Colombo, pp. 161, pls. 48. August, 1955.

DETWILER, S. R. The eye and its structural adaptations. Proc. Amer. Philos. Soc., vol. 99, no. 4, pp. 224–238, illus. August 30, 1955.

DUMAIS, ROLLAND. Les mammifères de mon pays. Éditions Courvilliennes, Quebec, pp. 189, illus. 1955.

DUNKESON, ROBERT L. Deer range appraisal for the Missouri Ozarks. Jour. Wildlife Management, vol. 19, no. 3, pp. 358–364, illus. July, 1955.

DUNNET, G. M. Records of small mammals and their fleas from eastern North Tyrol, Austria. Ann. & Mag. Nat. Hist., London, vol. 8, no. 89, pp. 385–389. May, 1955.

DUNNET, G. M. Records of small mammals and their fleas from Reinosa, Santander, Spain. Ann. & Mag. Nat. Hist., London, vol. 8, no. 90, pp. 445–448. June, 1955.

DURHAM, FLOYD E. Variations and adaptations of the rodents of the north rim of the Grand Canyon, Arizona. Essays in the Natural Sciences in Honor of Captain Allen Hancock, Univ. Southern California, Los Angeles, pp. 233–258, 2 maps. July 26, 1955.

DURRANT, STEPHEN D. A new pocket gopher from south-central Utah. Proc. Biol. Soc. Washington, vol. 68, pp. 79–82. August 3, 1955. (New: *Thomomys bottae powelli*.)

EADS, R. B., J. S. WISEMAN, J. E. GRIMES, AND G. C. MENZIES. Wildlife rabies in Texas—a preliminary report. Public Health Repts., U. S. Public Health Service, Washington, vol. 70, no. 10, pp. 995–1000. October, 1955.

EIBL-EIBESFELDT, IRENÄUS. Boebachtungen über territoriales Verhalten und Brutpflege des Galápagos-Seelöwen. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 75–77. August 3, 1955.

ELLERMAN, J. R., AND T. C. S. MORRISON-SCOTT. Supplement to Chasen (1940) A Handlist of Malaysian Mammals, containing a generic synonymy and a complete index. British Museum (Natural History), London, pp. 66. March 26, 1955.

FELTEN, H., AND C. KÖNIG. Einige Säugetiere aus dem Zentralmassiv, Südfrankreich. Senckenbergiana Biologica, Frankfurt a. M., vol. 36, nos. 3–4, pp. 267–269. July 15, 1955.

FETISOV, A. S. K rasprostraneniyu i ekologii polevki vinogradova (Phaiomys vinogradovi Fetissov) v vostochnoi sibiri. Doklady Akad. Nauk SSSR, vol. 104, no. 2, pp. 326–328. 1955.

FRASER, F. C. A skull of *Mesoplodon gervaisi* (Deslongchamps) from Trinidad, West Indies. Ann. & Mag. Nat. Hist., ser. 12, vol. 8, no. 92, pp. 624–630. August, 1955.

FRENCH, C. E., L. C. MCEWEN, N. D. MAGRUDER, R. H. INGRAM, AND R. W. SWIFT. Nutritional requirements of white-tailed deer for growth and antler development. Bull. Penn. State Univ. Agric. Exper. Sta., nos. 600 and 600P, pp. 50 + 8, illus. July, 1955.

FRITSCHE, KARL. Wildkatze bei Bremerhaven. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, p. 183. August 3, 1955.

GAFFREY, GÜNTER. Zur Biologie der Hausratte, *Rattus rattus* L. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, p. 183. August 3, 1955.

GAUNT, W. A. The development of the molar pattern of the mouse (Mus musculus). Acta Anatomica, Basel, vol. 24, nos. 3–4, pp. 249–267. 1955.

GAZIN, C. LEWIS. A review of the Upper Eocene Artiodactyla of North America. Smithsonian Misc. Coll., Washington, vol. 128, no. 8, pp. 1–96, illus. September 28, 1955. (New: *Pentacemylus leotensis; Mytonomeryx, M. scotti; Protoreodon petersoni; Diplobunops vanhouteni;* Oromerycidae, new family; *Malaquiferus, M. tourteloti; Poëbrodon, P. kayi; Leptotragulus clarki*)

GEE, E. P. The Indian elephant (*E. maximus*): early growth gradient and intervals between calfing. Jour. Bombay Nat. Hist. Soc., vol. 53, no. 1, pp. 125–128, illus. August, 1955.

GEURDEN, L. M. G. Les facteurs physio-pathologiques influençant l'acclimatation de l'okopi. Bull. Soc. Roy. Zool. Anvers, no. 3, pp. 3–21, illus. 1953.

GODFREY, G. K. A field study of the activity of the mole (*Talpa europaea*). Ecology, vol. 36, no. 4, pp. 678–685, illus. 1955.

GOODWIN, GEORGE G. Mammals from Gautemala, with the description of a new little brown bat. Amer. Mus. Novitates, New York, no. 1744, pp. 1–5. August 12, 1955. (New: *Myotis velifer cobanensis*)

GOPALAKRISHNA, A. Observations on the breeding habits and ovarian cycle in the Indian sheath-tailed bat, *Taphozous longimanus* (Hardwicke). Proc. Nat. Inst. Sci. India, Calcutta, vol. 21, pt. B, no. 1, pp. 29–41, illus. February 26, 1955.

GOULD-MARKS, LANGTON. The great grey kangaroo. Zoo Life, London, vol. 9, no. 2, pp. 55–57, illus. Summer, 1954.

GRAY, JAMES. The flight of animals. Ann. Rept. Smithsonian Inst., Washington, 1954, pp. 285–303, pls. 1–10. 1955.

GUIGUET, C. J. Undescribed mammals (*Peromyscus* and *Microtus*) from the islands of British Columbia. Rept. Provincial Mus. Nat. Hist. & Anthropol., Victoria, British Columbia, 1954, pp. B64–B76. August 8, 1955. (New: *Microtus townsendi cowani, Peromyscus maniculatus triangularis, P. m. sartinensis, P. m. beresfordi, P. m. carli.*)

GUILDAY, JOHN E. Animals remains from an Indian Village Site, Indiana County, Pennsylvania. Pennsylvania Archaeologist, vol. 25, no. 2, pp. 142–147, August, 1945.

HAMILTON, WM. J., JR. Nature spreads a varied table. Animal Kingdom, New York Zool. Soc., vol. 58, no. 4, pp. 98–103, illus. July–August, 1955.

HAMILTON, WM. J., JR. Two new rice rats (genus *Oryzomys*) from Florida. Proc. Biol. Soc. Washington, vol. 68, pp. 83–86. August 3, 1955. (New: *O. palustris planirostris, O. p. sanibeli.*)

HANDLEY, CHARLES O., JR. New bats of the genus *Corynorhinus*. Jour. Washington Acad. Sci., vol. 45, no. 5, pp. 147–149. May 23, 1955. (New: *C. townsendii australis, C. t. ingens, C. t. virginianus.*)

HANSTRÖM, BERTIL. Nyare uppgifter om björkmusens (*Sicista betulina*) utbredning i Bergslagen. Fauna och Flora, pts. 4–5, pp. 129–138. 1955. (In Swedish, with English summary)

HARRISON, J. L. Data on the reproduction of some Malayan mammals. Proc. Zool. Soc. London, vol. 125, pt. 2, pp. 445–460. August 31, 1955.

HAYMAN, R. W. Mammals of Australasia. Zoo Life, London, vol. 9, no. 2, pp. 44–51, illus. Summer, 1954.

HAYMAN, R. W. Mammals of Sierra Leone. Zoo Life, London, vol. 10, no. 1, pp. 2–6, illus. Spring, 1955.

HELLER, FLORIAN, AND HANS E. KAISER. Pathologische Beobachtungen an fossilen Nagern und anderen Kleinwirbeltieren, eine Übersicht. Zentralbl. Pathol., vol. 93, pp. 383–395. 1955.

HERMAN, CARLTON M., AND JAMES R. REILLY. Skin tumors on squirrels. Jour. Wildlife Management, vol. 19, no. 3, pp. 402–403, illus. July, 1955.

HEROLD, WERNER. Zahnverschmelzung bei einer Gelbhalsmaus (*Apodemus flavicollis* Melch.) Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 184–186. August 3, 1955.

HERTER, KONRAD, AND GERHARD LAUTERBACH. Die Überwinterung syrischer Goldhamster (*Mesocricetus auratus* Waterh.) in Norddeutschland. Zeitschr. Säugetierk. Berlin, vol. 20, nos. 2–3, pp. 37–54, illus. August 3, 1955.

HIBBARD, CLAUDE W. The Jinglebob interglacial (Sangamon?) fauna from Kansas and its climatic significance. Contrib. Mus. Paleontol. Univ. Michigan, vol. 12, no. 10, pp. 179–228, 2 pls., chart. September 1, 1955. (New: *Onychomys jinglebobensis, Peromyscus cochrani, Oryzomys fossilis, Zapus adamsi*)

HICKLING, G., A. W. JONES, AND I. M. TELFER. The grey seals of the Farne Islands. Trans. Nat. Hist. Soc. Northumberland, Durham, & Newcastle upon Tyne, n.s., vol. 11, no. 7, pp. 153–163. 1955.

HILL, W. C. OSMAN. Primates: comparative anatomy and toxonomy. II. Haplorhini: Tarsioidea. University Press, Edinburgh; Interscience, New York, pp. 347, illus. 1955.

HOFFMEISTER, DONALD F. Descriptions of pocket gophers (*Thomomys bottae*) from northeastern Arizona. Jour. Washington Acad. Sci., vol. 45, no. 4, pp. 126–128. April 25, 1955. (New: *T. b. rufidulus.*)

HOOIJER, D. A. Fossil Proboscidea from the Malay Archipelago and the Punjab. Zool. Verhand. Mus. Leiden, no. 28, pp. 1–146, illus. August 31, 1955.

ILSE, D. R. Olfactory marking of territory in two young male loris, *Loris tardigradus lydekkerianus*, kept in captivity in Poona. British Jour. Animal Behaviour, London, vol. 3, no. 3, pp. 118–120, illus. July, 1955.

IRVING, LAURENCE, HILDUR KROG, AND MILDRED MONSON. The metabolism of some Alaskan animals in winter and summer. Physiological Zoology, vol. 28, no. 3, pp. 173–185. July, 1955.

JANOSSY, D. Fossile Microtinen aus dem Karpatenbecken, I. Lemminge. Ann. Hist.-Nat. Mus. Nat. Hungarici, n.s., vol. 5, pp. 39–48, illus. 1954.

JANOSSY, D. Stosszahnfund eines zygodonten Mastodons aus dem Levantikum von Balatonszentgyörgy. Ann. Hist.-Nat. Mus. Nat. Hungarici, n.s., vol. 6, pp. 87–92, illus. 1955.

JOHNSTON, P. M., AND J. A. SEALANDER. The normal histology of brown fat of certain Arkansas bats. Proc. Arkansas Acad. Sci., vol. 7, pp. 50–54, illus. 1955.

JONSGÅRD, ÅGE. The stocks of blue whales (*Balaenoptera musculus*) in the northern Atlantic Ocean and adjacent Arctic waters. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 9, pp. 505–519. September, 1955.

KELLY, JOAN MORTON. Gorilla "Twenty Questions." Zoonooz, Zool. Soc. San Diego, vol. 28, no. 6, pp. 3–6, illus. June, 1955.

KEMNA, ALWIN. Knochensystem-Erkrankung bei Kapuzineraffen. Zool. Garten, Leipzig, n.f., vol. 21, no. 3, pp. 167–171, illus. 1955.

KENYON, KARL W., AND VICTOR B. SCHEFFER. The seals, sea-lions, and sea otter of the Pacific coast. Circular U. S. Fish & Wildlife Ser., no. 32, pp. 34, illus. April, 1955.

KOWALSKI, KAZIMIERZ. Rytmika dobowa aktywności nietoperza "Myotis myotis" Borkhausen. Folia Biologica, vol. 3, pt. 1, pp. 55–64. 1955. (Daily rhythm of activity. In Polish, with Russian and English summaries.)

KOWALSKI, KAZIMIERZ. Nasze nietoperze i ich ochrona. Zaklad Ochrony Przyrody, Polska Akad. Nauk, Krakow, on. 11, pp. 110, illus. 1955. (Chiroptera.)

KREFTING, L. W., A. B. ERICKSON, AND V. E. GUNVALSON. Results of controlled deer hunts on the Tamarac National Wildlife Refuge. Jour. Wildlife Management, vol. 19, no. 3, pp. 346–352. July, 1955.

KRISHNA, DAYA, AND ISHWAR PRAKASH. Hedgehogs of the desert of Rajasthan. Jour. Bombay Nat. Hist. Soc., vol. 53, no. 1, pp. 38–43, illus. August, 1955.

KÜHLHORN, JOHANNES. Der Auerochs von 1595. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, p. 186. August 3, 1955.

LANGE, RICHARD. In Gebäuden eines Erzgebirgs-Dorfes überwinternde Kleinsäuger. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 187–189. August 3, 1955.

LAWS, R. M. Natural history of the larger whales. Zoo Life, London, vol. 10, no. 2, pp. 41–46, illus. Summer, 1955.

LECHLEITNER, R. R. Mammals of Glacier National Park. Bull. Glacier Nat. Hist. Assoc., West Glacier, Montana, no. 6, pp. 92, illus. August, 1955.

LENSINK, C. J., R. O. SKOOG, AND J. L. BUCKLEY. Food habits of marten in interior Alaska and their significance. Jour. Wildlife Management, vol. 19, no. 3, pp. 364–368. July, 1955.

LIDICKER, W. Z., AND W. H. DAVIS. Changes in splenic weight associated with hibernation in bats. Proc. Soc. Exper. Biol. & Med., New York, vol. 89, no. 4, pp. 640–642. August–September, 1955.

LOCHTE, TH. Das Haar des Braunbären, Grizzlybären und ihres Mischlings. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 163–167, illus. 1955.

MAKINO, S., K. KANO, AND M. TAKAHASHI. Breeding experiments of white rats and mice, V. Further data on breeding rats with descriptions of sixteen rat strains. Misc. Repts. Yamashina's Inst. Ornithol. & Zool., Tokyo, no. 6, pp. 22–29. June, 1955. (In Japanese, with English summary.)

MANSUETI, R. Seal strays into Maryland waters. Maryland Tidewater News, Solomons, vol. 12, no. 3, pp. 1–3. August, 1955.

MARSHALL, I. D., A. L. DYCE, W. E. POOLE, AND FRANK FENNER. Studies in the epidemiology of infectious myxomatosis of rabbits. IV. Observations of disease behaviour in two localities near the northern limit of rabbit infestation in Australia, May 1952 to April 1953. Jour. Hygiene, vol. 53, no. 1, pp. 12–25. March, 1955.

MCKENNA, MALCOLM C. Earliest Eocene vertebrates from the Sand Wash Basin, north-

western Colorado. Guidebook to the Geology of northwestern Colorado, Joint Field Conference Intermountain Assoc. Petroleum Geologists and Rocky Mountain Assoc. Geologists, pp. 41–43, illus. 1955.

McKenna, Malcolm C. Age of the Four Mile local fauna, northeast Sand Wash Basin, Colorado. Wyoming Geol. Assoc. Guidebook, 10th Ann. Field Conference, pp. 105–107, illus. 1955.

McKenna, Malcolm C. A new species of mylagaulid from Chalk Cliffs local fauna. Jour. Washington Acad. Sci., vol. 45, no. 4, pp. 107–110, illus. April 25, 1955. (New: *Mylagaulus douglassi*.)

Nichols, Una G. Little camel of the south. Zoonooz, Zool. Soc. San Diego, vol. 28, no. 9, pp. 5–7, illus. September, 1955. (Guanaco)

Ogilvie, Charles S. Malayan seladang. Animal Kingdom, New York Zool. Soc., vol. 58, no. 1, pp. 2–12, illus. February, 1955.

Omura, Hideo. Whales in the northern part of the North Pacific. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 6, pp. 323–342, no. 7, pp. 395–405, illus. June, July, 1955.

Paula Couto, Carlos de. O "Tigre-dentes-de-sabre" do Brasil. Bol. Conselho Nacional de Pesquisas, no. 1, pp. 1–30, illus. 1955.

Peterson, Willis. Arizona's operation Beaver Lift. Nat. Geogr. Mag., Washington, vol. 107, no. 5, pp. 666–680, illus. May, 1955.

Petrides, George A. Kenya's wild-life resource and the national parks. Royal National Parks of Kenya, Nairobi, pp. iii + 24. March 15, 1955.

Petzsch, Hans. Boebachtungen an den Elbe-Bibern (*Castor fiber albicus* Matschie) des halleschen Tiergartens. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 156–160, illus. 1955.

Petzsch, Hans. Gesellschaftshaltung einer grösseren Anzahl von Iltissen (Putorius putorius [L.]) und Frettchen (Putorius furo [L.]) verschiedener Altersstufen. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 188–190, illus. 1955.

Pfeiffer, E. W. Hormonally induced "mammary hairs" of a primitive rodent Aplodontia rufa. Anat. Record, vol. 122, no.2, pp. 241–255, illus. June, 1955.

Pournelle, George H. Primitive primates. Zoonooz, Zool. Soc. San Diego, vol. 28, no. 8, pp. 1–4, illus. August, 1955.

Prakash, Ishwar, and S. C. Sharma. Nematodes and hedgehog mortality. Jour. Bombay Nat. Hist. Soc., vol. 53, no. 1, p. 123. August, 1955.

Presnall, Clifford C. Wildlife rabies control. Public Health Repts., U. S. Public Health Service, Washington, vol. 70, no. 12, pp. 1216–1217. December, 1955.

Rousseau, J. Basic principles for the protection of the barren ground caribou and reindeer breeding in Quebec. Ann. Rept. Prov. Quebec Assoc. Prot. Fish & Game, 1951, pp. 28–35. 1953.

Rowley, Ian, and B. C. Mollison. Copulation in the wild rabbit, *Oryctolagus cuniculus*. Behaviour, vol. 8, no. 1, pp. 81–84. 1955.

Salmi, Martti. Additional information on the findings in the Mylodon cave at Ultima Esperanza. Acta Geographica, vol. 14, no. 9, pp. 314–333, illus. 1955.

Sanderson, Ivan T. Living mammals of the world. Hanover House, Garden City, New York, pp. 303, illus. 1955.

Scherman, Katharine, and Richard S. Miller. Creatures of sea ice and tundra barrens. Animal Kingdom, New York Zool. Soc., vol. 58, no. 2, pp. 56–61, illus. April, 1955. (*Phoca hispida*)

Schmidt-Nielsen, Bodil, Urea excretion in white rats and kangaroo rats as influenced by excitement and by diet. Amer. Jour. Physiol., Washington, vol. 181, no. 1, pp. 131–139. April, 1955.

Schroeder, C. R. The role of bats in the transmission of rabies. Essays in Natural Sciences in Honor of Captain Allen Hancock, Univ. Southern California, Los Angeles, pp. 221–232, illus. July 26, 1955.

SCHULZE, WILHELM. Nephritis beim Zwergflusspferd. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, p. 188. 1955.

SCOTT, JACK DENTON. Mammal man. Coronet, Chicago, vol. 38, no. 3, pp. 40–43. July, 1955. (V. H. Cahalane)

SCOTT, THOMAS, G. An evaluation of the red fox. Biol. Notes Illinois Nat. Hist. Survey Div., Urbana, no. 35, pp. 16, illus. July, 1955.

SEALANDER, JOHN A., AND HOWARD YOUNG. Preliminary observations on the cave bats of Arkansas. Proc. Arkansas Acad. Sci., vol. 7, pp. 21–31, illus. 1955.

SEALANDER, JOHN A., JR., AND BARRY O. WALKER. A study of the cotton rat in northwestern Arkansas. Proc. Arkansas Acad. Sci., vol. 8, pp. 153–162. 1955.

SEITZ, ALFRED. Eisbärenzucht 1952 in Nürnberg. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 161–163, illus. 1955.

SLEPTSOV, M. M. Cetaceans of the seas of the Far East. Pacific Research Inst. Fisheries & Oceanogr., Ministry Fisheries USSR, Vladivostok, pp. 162, illus. 1955. (In Russian.)

SLEPTSOV, M. M. Biology and whaling in the seas of the Far East. Food Industry Publishing House, Moscow, pp. 64, illus. 1955. (In Russian.)

SMITH, ELIZABETH. A new apparatus for long term measurement of oxygen consumption in small mammals. Proc. Soc. Exper. Biol. & Med., New York, vol. 89, no. 4, pp. 499–501. August, 1955.

SOUTHWICK, CHARLES H. The black howlers of Barro Colorado. Animal Kingdom, New York Zool. Soc., vol. 58, no. 4, pp. 104–109, illus. July-August, 1955. (*Alouatta*)

STEIN, GEORG H. W. Die Kleinsäuger ostdeutscher Ackerflächen. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 89–113. August 3, 1955.

STEUER, H. Brucellose beim Wasserbüffel. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 171–173. 1955.

STEVEN, D. M. Untersuchungen über die britischen Formen von *Clethrionomys*. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 70–74. August 3, 1955.

SWANEPOEL, P. D. My first encounter with a black rhino. African Wildlife, Johannesburg, vol. 9, no. 3, pp. 209–210, illus. September, 1955.

SWYNNERTON, G. H. Notes on fauna. I Mammals. Ann. Rept. Tanganyika Game Dept., 1954, pp. 22–30, illus. 1955.

SYMONS, H. W. The foetal growth rate of whales. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 9, pp. 519–528, illus. September, 1955.

TAKAHASHI, M. Morphological study of the sperm-head in some American rodents. Misc. Repts. Yamashina's Inst. Ornithol. & Zool., Tokyo, no. 6, pp. 30–33. June, 1955. (In Japanese, with English summary.)

TAYLOR, DWIGHT W., AND C. W. HIBBARD. A new Pleistocene fauna from Harper County, Oklahoma. Cir. Oklahoma Geol. Surv., no. 37, pp. 23, illus. 1955.

TAYLOR, F. H. C., M. FUJINAGA, AND FORD WILKE. Distribution and food habits of the fur seals of the North Pacific Ocean. U. S. Fish & Wildlife Service, Washington, pp. x + 86. 1955.

TEDFORD, RICHARD H. Report on the extinct mammalian remains at Lake Menindee, New South Wales. Rec. South Australian Mus., vol. 11, no. 3, pp. 299–305. February 28, 1955.

TEGNER, H. S. The past and present distribution of roe deer in Northumberland. Trans. Nat. Hist. Soc. Northumberland, Durham and Newcastle upon Tyne, n.s., vol. 11, no. 7, pp. 164–168. 1955.

THOMPSON, KATHLEEN M. Nutria farming. Amer. Fur Breeder, Duluth, vol. 28, no. 9, pp. 18, 58–60. September, 1955.

TOSCHI, AUGUSTO. Elenco preliminare dei mammiferi della Libia. Suppl. Ricerche Zool. Applic. Caccia, Univ. Bologna., vol. 2, no. 7, pp. 241–273. December, 1954. (Checklist.)

ULLRICH, WOLFGANG. Vegatative Neurose eines Schimpansen. Zool. Garten, Leipzig, N.F., vol. 21 no. 3, p. 190. 1955.

ULLRICH, WOLFGANG. Belebungsversuche an einem jungen Löwen. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, p. 193. 1955.

VAN DEN BERGH WALTER. Nos rhinocéros blancs (*Ceratotherium simum cottoni* Lydekker). Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 129–151, illus. 1955.

VANDERMANDER, A. Aperçu succint de nos connaissances actuelles au sujet de l'okopi. Bull. Soc. Roy. Zool. Anvers, vol. 3, pp. 22–43, illus. 1953.

VANZOLINI, P. E., AND L. R. GUIMARÃES. South American land mammals and their lice. Evolution, Lancaster, vol. 9, no. 3, pp. 345–347. September, 1955.

WALKER, ERNEST P. First aid and care of small animals. Animal Welfare Inst., 46 pp., illus. 1955.

WEALE, R. A. Bleaching experiments on eyes of living grey squirrels (*Sciurus carolinensis leucotis*). Jour. Physiol., London, vol. 127, no. 3, pp. 587–591. March, 1955.

WEBB, M. M. C. S., AND A. REVENTLOW. L'acclimatation des okopis a Londres et Copenhague. Bull. Soc. Roy. Zool. Anvers, vol. 3, pp. 45–54, illus. 1953.

WIJNGAARDEN, A. VAN. Vorläufige Ergebnisse der Populations-untersuchung an Feldmäusen in der Betuwe. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 61–69, illus. August 3, 1955.

WOOD, JOHN E. Notes on reproduction and rate of increase of raccoons in the post oak region of Texas. Jour. Wildlife Management, vol. 18, no. 3, pp. 409–410. July, 1955.

YIN, U TUN. Tufted deer in Burma (*Elaphodus cephalophus* Milne-Edwards). Jour. Bombay Nat. Hist. Soc., vol. 53, no. 1, pp. 123–125, illus. August, 1955.

ZEUNER, F. E. The chronology of the Mousterian at Gorham's Cave, Gibraltar. Proc. Prehist. Soc., vol. 19, pt. 2, pp. 180–188. 1953.

ZEUNER, F. E. Pleistocene man in Italy and Germany. Man, no. 80, pp. 1–2. 1954.

ZIM, HERBERT S., AND DONALD F. HOFFMEISTER. Mammals: a guide to familiar American species. Simon & Schuster, New York, pp. 160, illus. 1955.

ZIMMERMANN, KLAUS. Körpergrösse und Bestandsdichte bei Feldmäusen (*Microtus arvalis*). Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 114–118, August 3, 1955.

ZIMMERMANN, KLAUS. Zur Fauna Afghanistans. Zeitschr. Säugetierk., Berlin, vol. 20, nos. 2–3, pp. 189–191. August 3, 1955.

ZUKOWSKY, LUDWIG. Ungewöhnlicher Haarwechsel bei enem Siampanther des Münsterschen Zoos. Zool. Garten, Leipzig, N.F., vol. 21, no. 3, pp. 193–194. 1955.

COMMENTS AND NEWS

ANNUAL MEETING

Higgins Lake, Michigan will be the site of the 36th Annual Meeting, June 16–20, 1956. Directors meet the evening of June 16 and the program begins the morning of June 17. For further details see the February issue.

SHERMAN TRAPS AVAILABLE

Mammalogists will be interested to know that both folding and non-folding Sherman live traps are now available from H. B. Sherman, P. O. Box 683, De Land, Florida.

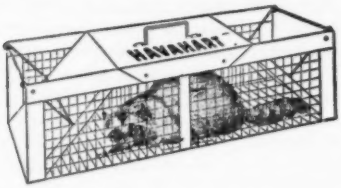
DEATHS REPORTED

Lowell S. Miller, December, 1955
Gerrit S. Miller, Jr., February 24, 1956

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 37, No. 1 was mailed February 28, 1956

HAVAHART HUMANE ANIMAL TRAPS



The *Allcock Manufacturing Company* has a large variety of humane animal traps. They have many sizes of live traps for those who are interested in catching the animals unharmed. The HAVAHART TRAPPING BOOKLET will be sent free of charge to anyone who requests it from the *Allcock Manufacturing Company, Ossining, New York.* HAVAHART traps have been used sucessfully by many who have been doing live-trapping experiments on small mammals. Write for the free booklet today.

SALE

Back Numbers of
JOURNAL OF MAMMALOGY

Vol. 1, no. 5, each	$2.50	Vol. 20, no. 3, each	$2.00
Vol. 3, no. 1, Lithoprinted	2.00	Vols. 22–26, each	5.00
Vol. 4	6.00	Vol. 27, nos. 2, 3, 4, each	1.25
Vol. 6	6.00	Vol. 28	5.00
Vols. 7–19, each	5.00	Vol. 29, nos. 3, 4, each	1.25

Vols. 30–33 ..... $5.00 each

A discount of *20 per cent* is allowed members in good standing.

Prices are subject to change without notice; orders will be filled only as copies are available.

INDEX TO JOURNAL OF MAMMALOGY

The index to the first 20 volumes, 1919–1939 inclusive, of this Journal is still available. Paper cover, $2.50; cloth, $3.50.

The ten-year index, 1940–1949, is now available. Paper cover, $3.25; cloth, $3.75.

RECENT LITERATURE AND MEMBERSHIP LIST,

REPRINTS FOR SALE

Reprints of the section on *Recent Literature* are for sale at 18¢ per number or 70¢ per volume. Supply available beginning with Volume 11 (1930)

Send orders for any of above to GEORGE C. RINKER, Corresponding Secretary, DEPARTMENT OF ANATOMY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN, *but made payable to the American Society of Mammalogists.*

CONTENTS

PAGE

Behavior of Columbian Black-tailed Deer with Reference to Population Ecology
Raymond F. Dasmann and Richard D. Taber 143
Territorialism in Deer ..... *William Graf* 165
Nocturnal Movements and Behavior of Wild Raccoons at a Winter Feeding Station
Ward M. Sharp and Louise H. Sharp 170
Studies of Maternal Retrieving in Rats. I: Recognition of Young
Frank A. Beach and Julian Jaynes 177
Ecology and Health of *Rattus* at Nome, Alaska ..... *Everett L. Schiller* 181
Responses of Small Mammal Populations to Logging of Douglas-fir .. *Lloyd Tevis, Jr.* 189
Notes on the Life History of *Napaeozapus* ..... *Norman A. Preble* 197
Molt in the Pocket Gopher, *Thomomys bottae*
G. Victor Morejohn and Walter E. Howard 201
The Reproductive Cycle of the Field Mouse, *Microtus californicus*
Gilbert S. Greenwald 213
Notes on Reproduction in the Star-nosed Mole
W. Robert Eadie and W. J. Hamilton, Jr. 223
Further Notes on Antlers in Female Deer of the Genus *Odocoileus* .. *George B. Wislocki* 231
Bronchial Diverticula in *Blarina brevicauda* ..... *Wesley W. Parke* 236
Morphology of the Scent Gland of the Javelina ..... *Glenwood P. Epling* 246
Aging Meadow Mice, *Microtus californicus*, by Observation of Molt Progression
Dean H. Ecke and Alta R. Kinney 249
Color Phases of the Roof Rat, *Rattus rattus* ..... *James W. Caslick* 255
Mammals from Kurdistan, Iraq, with Description of a New Bat .. *David L. Harrison* 257
New Aplodontid Rodent from Montana Oligocene ..... *John C. Donohoe* 264
General Notes 269

A Plea for an Adequate Color Standard, *Joseph A. Davis, Jr.;* Mammals from Eastern Nebraska, *Ralph Velich;* Mammals from Sado Island, Japan, with Comments on the Status of *Apodemus argenteus, J. Knox Jones, Jr. and Yoshinori Imaizumi;* An Early Record of a Marsupial in Ceylon, *David H. Johnson;* Keeping Short-tailed Shrews in Captivity, *Peter M. Mann;* Possible Himalayan Color Pattern in the Masked Shrew, *James S. Findley;* A Record of *Sorex merriami* from Northeastern Colorado, *Donald F. Hoffmeister;* Merriam Shrew, *Sorex merriami,* in Colorado, *Andrew Starrett and Priscilla Starrett;* Merriam Shrew in New Mexico, *James S. Findley;* Immature Water Shrews Found in a Beaver Lodge, *Hilbert R. Siegler;* A Third Specimen of the Shrew *Notiosorex* from Oklahoma, *Charles O. Handley, Jr.; Suncus murinus,* a Recent Introduction to Guam, *George D. Peterson, Jr.;* Bat versus Ant, *Charles O. Handley, Jr.;* An Observation on Quadruplets in the Red Bat, *Ross L. Packard;* Winter Range of the Red Bat, *Lasiurus borealis, Wayne H. Davis and William Z. Lidicker, Jr.;* Third Record of the Hoary Bat in Florida, *H. B. Sherman;* A Record of a Silver-haired Bat in a Cave, *James R. Beer;* Additional Records of *Nycticeius* in *Indiana, Dwight M. Lindsay;* The Pocketed Freetail Bat, *Tadarida femerosacca,* in Arizona, *E. Lendell Cockrum; Artibeus lituratus* in Morelos, Mexico, *Robert J. Russell;* The River Otter in Ohio, *Floyd B. Chapman;* Observations on a Domesticated Peruvian Desert Fox, *Dusicyon, Clarence Birdseye;* Archeological Evidence of the Fisher in West Virginia, *John E. Guilday;* Underwater Behavior of the Southern Sea Lion, *Otaria jubata, Chester C. Lindt;* Sperm Whales Stranded on the Beaches of the Gulf of California, *E. Lendell Cockrum;* The Manatee Along the Georgia Coast, *Ivan R. Tomkins;* Woodchuck Remains in Northern Arizona Caves, *Arthur L. Lange;* Extension of the Known Range of *Marmota monax* in Alaska, *Frederick S. Barkalow, Jr.;* Invasion of a Logged Area by Golden-mantled Squirrels, *Lloyd Tevis, Jr.;* Type Locality of the Mogollon Red Squirrel, *Tamiasciurus hudsonicus mogollonensis, Frances L. Burnett and Robert W. Dickerman;* Notes on a Population of Eastern Flying Squirrels, *James S. Jordan;* Reproduction in the Eastern Flying Squirrel in West Virginia, *Hans G. Uhlig;* Dental Formula in the Muroidea, *Robert W. Wilson;* Some Food Preferences in Field Mice, *A. A. Wellwood;* Albino *Microtus* Reared in the Laboratory, *E. I. Sillman and A. A. Wellwood:* Mal-arrangement of Teeth in *Clethrionomys gapperi, E. M. Reilly, Jr.;* Aquatic Tendencies in the Jumping Mouse, *R. W. Sutton;* Note on the Distribution of the Indian Crested Porcupine, *Hystrix indica, Louis Dupree;* Coprophagy in the Cottontail, *Charles M. Kirkpatrick;* Late Breeding in Moose, *Gaston Moisan.*

Reviews 301
Recent Literature 302
Comments and News 309